

New Scientist

WEEKLY October 15-21, 2016

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Laser power could shoot probe to Proxima Centauri

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The method is already being used to treat infertility



SIYQIAN/GETTY

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 Harriet Lee-Merrion

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A black and white portrait of Professor Dame Carol Robinson, a woman with dark, shoulder-length hair, smiling slightly. She is wearing a dark V-neck top with a small brooch on the left side.

Professor Dame Carol Robinson

2015 Laureate for United Kingdom

By Brigitte Lacombe



Science needs women

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Dame Carol Robinson, Professor of Chemistry at Oxford University, invented a ground-breaking method for studying how membrane proteins function, which play a critical role in the human body.

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CLOE WILLETTS/KAPITI NEWS/NZ HERALD

Beyond the binary

Science is catching up with society on transgender issues

OLLIE MAIHI, a 6-year-old from New Zealand, made headlines last week when her parents and school supported her request to live as a girl. Ollie (above) is anatomically male but identifies as female.

The decision was newsworthy because many psychologists discourage “social transitioning” at such a young age. Only around 25 per cent of young children who question their gender identity still question it by the time they reach puberty.

The *New Zealand Herald* also reported that once she turns 10, Ollie will start taking hormones to suppress puberty. That is a fairly common procedure for transgender children who are about to enter adolescence. The drugs buy time to decide whether to commence irreversible sex reassignment therapy, typically at 16. They also prevent the children from going through what endocrinologist Wylie Hembree at Columbia University in New York has called “the worst time of their life”, as their bodies develop in ways they find alien and distressing.

Nonetheless, it can be an agonising decision. The puberty-suppressing treatment is reversible, but its physical and psychological effects are not clear.

These decisions would be a lot

easier if there were biological markers that could help identify people who would benefit from early treatments. One interesting avenue of research is neuroscience, and an early study shows that the brain’s response to touch, for example, may differ between trans and non-trans individuals (see page 12). Such techniques may eventually be able to help guide children, parents and doctors when deciding what intervention,

“There could be tens of thousands of transgender children in US middle schools alone”

if any, to take – though a brain scan would never be the only factor.

Other avenues may open up. Earlier this year, *Nature* reported that the US National Institutes of Health was ramping up funding for research on the health of trans people, including the effects of blocking puberty. This, too, could lead to better-informed decisions.

The need for such a push is clear. A recent survey in New Zealand found that 1.2 per cent of children in high school identify as trans and 2.5 per cent say they are unsure about their gender. A survey of US middle school pupils reported a figure of 1.3 per

cent identifying as trans. Other studies have found that these young people have higher rates of depression, self harm, eating disorders and suicidal thoughts.

The prevalence figures are from small samples and must be considered provisional, but if they are right then there are tens of thousands of trans children in US middle schools alone. For many of them, the issue isn’t as simple as whether to transition to the gender they identify with. Trans children also include those who feel that their gender is somewhere between male and female, or entirely separate from the traditional binary. Their needs and the health issues they face must also be part of the surge in research interest.

Things are getting better for trans people. Stories like that of former Olympic decathlon champion Caitlyn Jenner, who last year came out as a trans woman, have helped to raise awareness and acceptance. Another trans 6-year-old, Coy Mathis, recently won the legal right to use the female bathroom at her school in Colorado. Progressive cultural and social change of this kind is thin on the ground at the moment. Science has a really big part to play in keeping the momentum going. ■



Hurricane's cholera legacy

HAITI is bracing itself for a surge in starvation and disease after hurricane Matthew hit the west of the country on 4 October. Around 1000 people are so far confirmed as being killed by the storm itself, but the death toll could soar as the knock-on effects of the devastation take hold.

In the hard-hit southern peninsula, crops were destroyed, livestock swept away and irrigation systems, docks and fishing boats damaged. That is serious in the western hemisphere's poorest nation, where most people are subsistence farmers. Many rural inhabitants were already malnourished after a three-year drought.

The World Food Programme is rushing in food aid, in some cases via boat and helicopter where roads and

bridges have been washed away. The Haitian government plans to distribute farming equipment and seed for winter crops such as potatoes until staples such as corn can be planted in the spring.

But while food is lacking, there is too much water. Widespread flooding is likely to have spread sewage from Haiti's crude sanitary systems. That would carry cholera bacteria, introduced by UN peacekeepers after Haiti's devastating earthquake in 2010 – something the UN finally admitted this year. Some 10,000 Haitians have died of cholera since the earthquake, with nearly 27,000 cases already this year. Almost 70 cases had been reported in remote parts of the storm-damaged region five days after the hurricane.

Aid group Operation Blessing

International prepared for the hurricane by ramping up production of chlorine for water treatment. But rural communities often use untreated surface water and groundwater prone to sewage contamination. "I am expecting that this hurricane will increase cholera rates, and also cholera death rates, if the floods cut off access to treatment facilities," says David Sack at Johns Hopkins University, Maryland.

The rains could offer some respite from diseases carried by mosquitoes, such as malaria, Zika, chikungunya and dengue, as the insects' breeding areas have been washed away, says Duane Gubler at Duke-NUS Medical School in Singapore. But those diseases could then roar back as receding floods leave puddles where mosquitoes can breed.

Glacial melt

THE snow-capped skyline of the Andes is beating a hasty retreat. Since the mid-1970s, the area covered by glaciers in southern Peru's Cordillera Vilcanota range has nearly halved, with most losses occurring below 5000 metres.

Glaciologists at the Federal University of Rio Grande do Sul in Brazil used Landsat images taken every decade to measure the snow line, finding that 48 per cent of the ice had disappeared since 1975 – with 81 per cent vanishing in areas below 5000 metres. As global warming continues, such tropical glaciers are likely to disappear (*Remote Sensing Letters*, doi.org/brph).

"The area covered by glaciers has halved, with 81 per cent vanishing in areas below 5000 metres"

The humid air that circulates in from the Amazon basin to the east should bring rain that replenishes the ice, but the high eastern glaciers are balding faster than their west-facing partners. At the moment, the reason for this disparity is unclear.

The Andes host more than 95 per cent of the world's tropical glaciers, a rich source of water for drinking, hydroelectric power and farming.

Dementia factors

THERE may be new ways to reduce the risk of dementia, hints the first comprehensive review of the influence of environment on incidence of the condition.

Looking at 60 past studies, Tom Russ at the University of Edinburgh, UK, and his team found plenty of evidence that air pollution is associated with dementia. "There weren't any studies that didn't find a link between air pollution and dementia," says Russ.

There was also a clear link with vitamin D deficiency, and an association with passive smoking and occupational exposure to pesticides (*BMC Geriatrics*, DOI: 10.1186/s12877-016-0342-y).

But Russ says it would be premature to advise people to limit their exposure to any of these things. Although some studies provide strong evidence of correlations, the team cannot definitively conclude that any of these factors cause dementia.

Existing advice recommends that people limit their risk by eating healthily, getting plenty of exercise and not smoking.

Clown contagion

IT'S not funny any more. Creepy clown sightings have now spread across the US, Australia and the UK, where police forces have dealt with a deluge of reports of "killer clowns" frightening the public.

So what's going on? The craze is spreading like a disease, says Nicholas Christakis at Yale University, who researches social contagion.

This kind of mass hysteria taps into a variety of fundamentals in the human psyche. "We're social animals, and we copy others and learn from them," says Christakis.

People start suddenly seeing things because others around them report seeing them. Then the behavioural contagion starts. It's a vicious circle: the more incidents that surface, the more dread this phenomenon evokes and the more people feel the need to participate.

One worry is that someone will use the panic to do genuine harm. Another is of retaliation. That may be starting already – as a report of a "clown hunt" in Australia suggests.

But why now? Mass hysterias tend to emerge in times of uncertainty, says Christakis. "Historically, these kinds of delusions happen when there is a lack of stability."

Pale blue dot hunt

LET'S take a look next door. A team of astronomers, entrepreneurs and philanthropists has launched an ambitious campaign to grab the first ever picture of a distant, possibly Earth-like world.

Project Blue hopes to launch a telescope the size of a washing machine into orbit, and point it at Alpha Centauri – our neighbouring star system. Although it is relatively close, we have never been able to capture a decent image of its planets.

That's because Alpha Centauri contains two bright stars whose

light overwhelms current telescopes, preventing them from picking out any worlds. The Project Blue team wants to build a bespoke telescope that suppresses the light from both stars, allowing planets to be seen directly.

"From orbit, the telescope should show each planet as a little dot, and might reveal signs of life"

The team expects that its images will show each world as a little dot. They might also contain enough information to reveal signs of life or an atmosphere.

Futuristic farm's first tomatoes

SUNSHINE and seawater: that's all a vast new greenhouse in the South Australian desert needs to produce 17,000 tonnes of tomatoes a year.

It's the first large-scale agricultural system of its kind and uses no soil, pesticides, fossil fuels or groundwater. As demand for fresh water and energy keeps rising, this might be the future face of farming.

An international team has spent the last six years fine-tuning the design – first with a pilot greenhouse built in 2010, then a commercial-scale facility that launched last week.

Seawater is piped 2 kilometres from the Spencer Gulf to Sundrop Farm, on a 20-hectare site in the arid Port Augusta region. A solar-powered desalination plant here yields

enough fresh water to irrigate 180,000 tomato plants inside the greenhouse.

The solar power is generated by 23,000 mirrors that reflect sunlight onto a 115-metre-high tower. On a sunny day, it produces up to 39 megawatts of power – enough for the desalination plant's and the greenhouse's electricity needs.

In winter, the greenhouse must still be hooked up to the grid, but gradual design improvements will eliminate that need in future, says Sundrop Farm's CEO Philipp Saumweber.

The farm's tomatoes are already on sale in Australian supermarkets, and the company is planning similar greenhouses in Portugal and the US.



A genuine solar farm

60 SECONDS

Cyber nuclear attack

A nuclear power plant was targeted by a cyberattack two to three years ago, according to the director general of the International Atomic Energy Agency. Yukiya Amano did not give details, but told Reuters that the hack caused "some disruption" and that the threat posed to nuclear facilities by cyberattacks was serious.

Opportunity's new job

It's a new mission for an old rover. Last week, NASA sent Opportunity into the Endeavour crater on Mars. There, it will explore a gully that may have been carved by water – a first for any Mars rover. Over the next two years, Opportunity will travel down the length of the gully and onto the crater floor.

Return of a goddess

A team of amateur conservationists in China say they have made a rare sighting of a baiji, or white dolphin, in the Yangtze river. Also known as the "goddess of the Yangtze", this dolphin species was declared functionally extinct 10 years ago, after inhabiting the river for 20 million years.

Cancer decline

The proportion of children dying from cancer in the US is declining. According to a report from the US National Center for Health Statistics, deaths from childhood cancer fell by 20 per cent between 1999 and 2014. Leukaemia caused the most childhood cancer deaths in 1999, but brain cancer caused the most in 2014.

Hearts get started

When does the heart start beating? For the first time, researchers have seen heart muscle cells contracting in mouse embryos less than eight days after conception. This is equivalent to 16 days in human embryos – five days earlier than they were previously thought to spring into action (*eLife*, doi.org/brpp).

'3-parent' method used for infertility

Andy Coghlan

THE first babies to be created using a "three-parent" method to overcome their parents' infertility are due to be born in early 2017. *New Scientist* has learned that two women in Ukraine are both more than 20 weeks pregnant with fetuses created using the same technique that has been legally approved in the UK.

The babies would be the first born to women who had such a procedure to treat infertility, rather than to prevent hereditary disease. But some have criticised this approach, calling for it to be banned until there is more evidence that it is safe.

The controversial technique was approved last year in the UK – the only country to legalise the procedure – but only to prevent parents passing mitochondrial diseases on to their children. No three-parent babies have been born in the UK yet, but a handful have elsewhere.

Valery Zukin, of the Clinic of Reproductive Medicine in Kiev, says his team has used the method to overcome embryo arrest, which happens when IVF embryos suddenly stop growing at around the two-cell stage.

"One, a girl, has now reached 26 weeks, and a boy has reached 20 weeks," says Zukin. His team plans to present their preliminary results at the American Reproductive Technology World Congress in New York this week.

Zukin's team used a technique called pronuclear transfer. In each case, they fertilised both the mother's egg and the egg of a donor with sperm from the husband. Then they extracted the pronucleus – the cell body that contains the chromosomes of both the mother and father – from the mother's fertilised egg. This was then used to replace the pronucleus in the fertilised donor egg, creating an embryo that had a full set of chromosomes from the parents, but potentially healthier

cellular machinery around it.

The idea is that there are factors within a cell's cytoplasm that can help or hinder fertility. By placing the pronucleus into a cell created using the egg of another woman, the hope is that whatever caused the embryo arrest can be avoided.

But Dean Betts at Western University in Canada says the reasons why embryos arrest are poorly understood. Using the process to overcome embryo arrest doesn't mean the underlying reason for it has been eliminated, possibly allowing

"The babies are due in early 2017, and would be the first born after using the method to treat infertility"

development of an abnormal embryo, he says. "I think it's too risky," says Betts. "I highly recommend banning this procedure in humans as we don't know enough to ensure its safety."

Zukin says the procedure was approved by an ethical committee and a board at the Ukrainian Association of Reproductive Medicine. Early DNA tests – including some conducted by an independent laboratory in Germany – have shown that the

two babies are genetically healthy, he says. Zukin is also waiting before repeating the procedure. "Some patients are awaiting similar embryo transfers, but we would like to be sure first that the babies are born healthy," he says.

Zukin isn't the first to try using such a method to treat infertility related to embryo arrest. John Zhang at the New Hope Fertility Center in New York attempted a similar procedure in 2003 and published an account of his results in August (*Reproductive Biomedicine Online*, doi.org/brnq).

While his team were able to produce three healthy fetuses, carried by one woman, they all died. One fetus was removed at 33 days, to relieve the pressure of bearing triplets, but the remaining two then died at 24 and 29 weeks respectively, due to rupturing membranes and umbilical cord prolapse.

But Zhang's analysis of fetal tissue revealed they all had normal chromosomes, leading his team to conclude that the technique could potentially be used to overcome embryo arrest.

Using three-parent methods to treat infertility raises ethical questions. If it works, it will dramatically increase the number of prospective parents who could benefit from these methods. An estimated 50 per cent of IVF procedures fail because embryos stop growing before they can be implanted.

A key argument considered by the UK parliament was that, for women with mitochondrial mutations, there are no other treatments. But there are other options for treating infertility, meaning some may be unhappy to see the method used in this way.

"There is much debate, and indeed, much pressure from the fertility world to get this treatment accepted," says Bert Smeets at Maastricht University in the Netherlands. "The fertility market is much bigger than the group of patients with mitochondrial disease." ■



On their way

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Laser could shoot probes to a nearby star

IF WE really want to send probes outside our solar system, interstellar disco balls propelled by lasers may be the way to go.

Earlier this year, billionaire Yuri Milner announced Breakthrough Starshot, an ambitious plan to send tiny probes through space at a fifth of the speed of light. At that pace, a probe could reach neighbouring star system Proxima Centauri in just 20 years.

The LightSail craft showed last year that it is possible for sails to propel spacecraft using sunlight. But to achieve the speeds required for interstellar travel, it might be better to use high-powered lasers shot from Earth. The principle is the same, but the sail's design will look completely different.

One challenge for Breakthrough Starshot will be keeping the sail's orientation just right in relation to the laser beam. Zachary Manchester and Abraham Loeb at Harvard University have now suggested a possible approach. Part of this involves using a spherical sail rather than the cone shape that others have suggested to help resolve orientation problems.

"I looked at the proposed laser-propelled sails and found that none of them would be very stable," says Manchester. "But I found that a spherical sail would be, and it's very elegant."

This sail would look a lot like a disco ball, with the probe hidden in the centre. When a laser beam hits its slender mirror-like surface, the light would bounce off and push the probe along. The beam would be weakest at its centre and strongest at its edges, helping to stabilise the probe when it is slightly off track (arxiv.org/abs/1609.09506).

"This solves a really interesting problem in a neat way," says Colin McInnes at the University of Glasgow, UK. "We're some way from achieving interstellar distances just yet, but this takes us one step closer."

Timothy Revell ■



FIONA ROGERS/CORBIS/GETTY

You tell me what I'm thinking

Apes can see things from the perspective of others

APES may be even more like us than we thought. They appear to anticipate that a person's actions will follow his or her beliefs, even when they know the beliefs are wrong – an ability never before demonstrated in non-human primates.

The capacity to infer what others might be thinking, known as theory of mind, is central to what makes us human, and is reflected in the ways we cooperate and communicate, says Christopher Krupenye at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany.

Humans, for example, possess an awareness of false beliefs held by other individuals, recognising that the thoughts of others don't necessarily reflect reality.

To see whether apes have this same type of awareness, Krupenye, Fumihiro Kano at Kyoto University in Japan, and their colleagues filmed scenarios designed to stimulate apes when played to them. The videos involve conflict between pairs of

human actors, one of whom is dressed in a King Kong costume.

In one video, the fake ape hits a person, and then hides in one of two haystacks while the person watches. After the human leaves the scene, "King Kong" exits the haystack and runs off-screen. The person then reappears, apparently looking for the attacker.

"This most sophisticated and significant of human skills may not be unique to us"

Because humans and other animals will look at a location where they anticipate action, the haystack that the apes glanced at first when they watched the video might indicate the one they expected the human to approach.

The researchers used a camera to track the eyes of 40 apes, including chimpanzees, bonobos and orangutans. Of the 30 that focused on the haystacks, two-thirds looked first at the one where the human falsely believed the character was hiding.

The scientists also tested the apes with a similar scenario, in which the King Kong character hides a stone in one of two boxes as a person watches, but then steals it when they leave.

When the person returns to look for the stone, about three-quarters of apes that paid attention to the boxes glanced first at the one that the human should open.

To test that the apes weren't just looking at the last place where they saw an object or character, the researchers filmed different versions of the videos. In these, King Kong briefly hides in the other haystack after the person leaves before dashing away, or transfers the stone to the other box without a person watching (*Science*, doi.org/brmq).

"They can anticipate that an individual will search for an object where they last saw it, even though the apes know that it's no longer there," Krupenye says. "That is a really important human skill that has never been shown before in apes."

This means that one of our most sophisticated and significant skills – reading the minds of others – is not unique to us, but also possessed by some of our evolutionary relatives, says Kano. Just like us, great apes have complex social lives bolstered by mutual understanding, he says.

Although the study demonstrates an exciting new method for testing apes' understanding, it raises more questions than it answers, says Laurie Santos at Yale University.

"We don't yet have a reason why primates fail other false-belief studies while succeeding on this," she says.

One possibility is that earlier studies tested for conscious understanding, whereas the new one demonstrates implicit knowledge similar to the kind that human infants display, says Alia Martin at Victoria University of Wellington in New Zealand. Emily Benson ■

Shaking out the universe's creases

Rebecca Boyle

HOW do you iron out the folds in a universe? Our most precise map of the big bang's afterglow – the cosmic microwave background (CMB) – is flawed, distorted by the gravity of giant galaxies warping the fabric of space-time. Like creases in a map that obscure part of a coastline or a continent, the distortions hide details about the primordial universe.

Now, Patricia Larsen at the University of Cambridge and her colleagues have a way to smooth out the map. The group is using the warmth emitted by dust in distant galaxies – the cosmic infrared background – to reverse the distortion.

Other teams are already trying this “de-lensing” method to remove the effect of gravity from telescope data, to better puzzle out physics mysteries.

If Larsen's technique is successful, it could reveal more about the leftover radiation from the big bang. For example, the way the rippling patterns of light in the CMB are polarised in a particular direction could correspond to gravitational

waves. These could in turn provide details on inflation, a rapid period of accelerated expansion thought to have taken place right after the big bang. The patterns might also help us infer the numbers and even mass of an elusive particle – the neutrino.

But galaxies throughout the universe get in the way: their mass warps the light of the CMB. This warping, or gravitational lensing, makes it impossible to see how the light is polarised.

However, we can remove that warping effect if we know where the massive galaxies are and compensate for their presence.

The light from galaxies that are too distant to be imaged by telescopes is absorbed by cosmic dust and re-emitted in the infrared spectrum. This generates a pattern similar to the CMB known as the cosmic infrared background. Bright spots correspond to areas dense with galaxies, which would also exert a greater gravitational lensing effect on the CMB.

“We have used the cosmic infrared background to figure out how to remove the gravitational lensing effect of the matter associated with those galaxies,”

says Larsen (*Physical Review Letters*, doi.org/brpf).

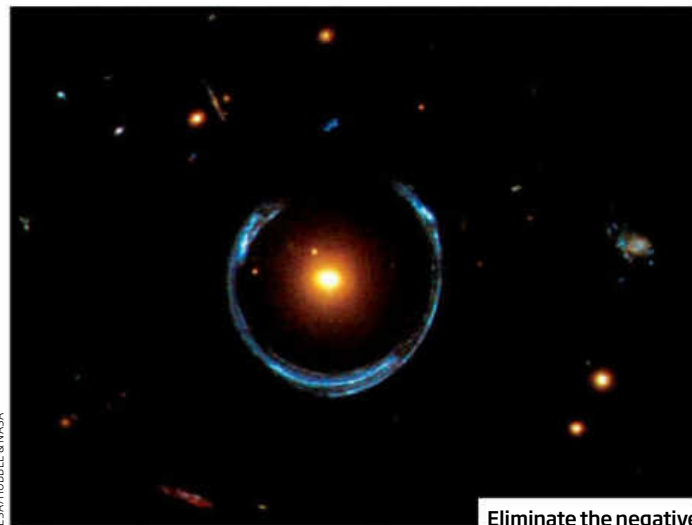
There have been attempts to use the CMB map itself to remove the distortion. Fluctuations in the density of the CMB give some indication of where gravitational lensing is taking place, Larsen says. But they are dominated by noise from other sources, which is why Larsen and her colleagues tried something different.

While their technique is a good proof of principle, it might not be much use with data from the European Space Agency's Planck satellite, which has produced maps of the CMB. Planck's maps are too coarse grained to pick out much more detail. But the method will pave the way for the more detailed views we will get from future telescopes.

“A confirmation that de-lensing works in practice as well as in theory is important,” says Larsen, particularly for experiments to detect polarisation from primordial gravitational waves.

People are already trying de-lensing on new CMB map data, including from the South Pole Telescope, says Marc Kamionkowski of Johns Hopkins University in Baltimore, Maryland.

Future high-resolution maps of the CMB will be even more valuable, says Kamionkowski, “but there is existing cosmic infrared background data that allows us to take some first steps now”. ■



Eliminate the negative

Virus steals black widow's poison gene

IT'S one of the most unexpected genetic thefts ever. A virus that infects bacteria has pinched the gene that codes for the poison of black widow spiders. The virus, named WO, probably uses the gene to help it attack its targets.

Viruses often steal genes from their hosts. But because bacterial viruses – also called bacteriophages –

only attack bacteria, genes from other domains of life are usually beyond their reach. That would include higher organisms known as eukaryotes, which have cells that contain a nucleus.

WO, however, faces an unusual challenge: its targets are *Wolbachia* bacteria living in the cells of insects, spiders and some other animals. That means that for it to attack new targets, WO has to escape not only from its existing *Wolbachia* host, but also from the eukaryotic cell. The virus particles must then evade the eukaryote's powerful immune system.

Many viruses of eukaryotic cells co-opt genes from their hosts to help them do this. To see if WO could do the same, microbiologists Sarah and Seth Bordenstein at Vanderbilt University in Nashville, Tennessee, sequenced its genome. They found several genes closely related to ones present in eukaryotes, including the gene for latrotoxin, the poison used by black widow spiders. It kills by poking holes

“The poison kills by poking holes in cell membranes, something useful to a virus escaping from a cell”

in cell membranes, making it a plausible tool for a virus needing to escape from a eukaryotic cell (*Nature Communications*, DOI: 10.1038/ncomms13155).

It is the first time eukaryotic genes have turned up in a bacterial virus. What's more, the eukaryote genes make up almost half of WO's genome.

This unusual gene theft shows the evolutionary adaptability of phage viruses, says Ry Young, director of the Center for Phage Technology at Texas A&M University, College Station. “They have evolved more than we have.” Bob Holmes ■

BAE SYSTEMS
INSPIRED WORK

[illegible]

Flower hijacks bee distress signal as a lure

A SOUTH AFRICAN plant is pollinated by scavenging flies, yet it offers them no scraps of food. So why do the flies flock to it? A scent that resembles the chemicals honeybees release when under attack seems to be key.

Many plants attract insect pollinators by exuding substances that mimic the smell of potential mates or rotting flesh. But the tricks many deceptive flowers play are still a mystery, says Stefan Dötterl at the University of Salzburg, Austria.

Dötterl and his colleagues focused on solving the mystery for *Ceropegia sandersonii*, a plant that produces “pitfall flowers”. These umbrella-shaped blossoms keep pollinators trapped within their petals for about a day before releasing them, now laden with pollen.

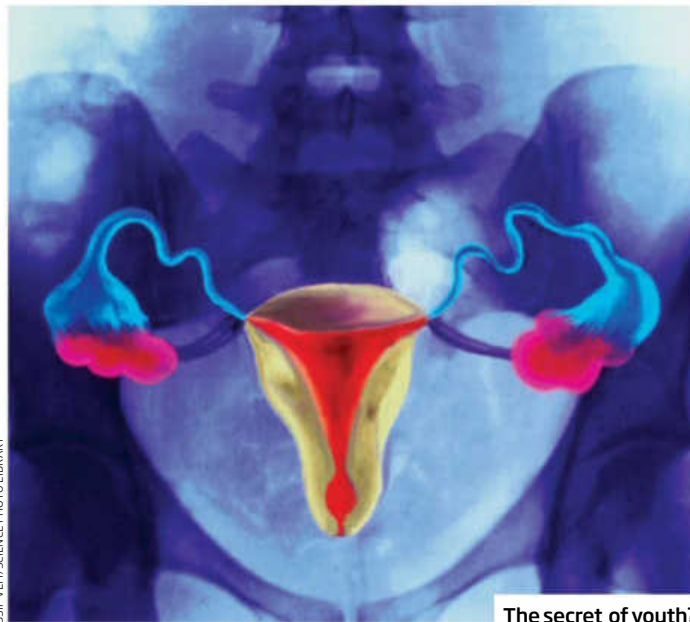
When the team gathered the insects imprisoned within the flowers, the most common type turned out to be a small fly that dines on the fluids left by spiders as they kill and eat honeybees. The researchers wondered if the plant could be exploiting the fly's dietary preferences.

To find out, Dötterl's team simulated an attack on the honeybees by squeezing them with their fingers or poking them with a narrow glass cylinder, then collected the defensive compounds the bees released. Analysis revealed several compounds common to those given off by the plant.

The flies can detect about half of those compounds, as subsequent experiments showed. When the researchers left out vials containing a blend of four of the substances given off by both the flowers and the bees, each one lured in about half a dozen flies in under an hour, while similar control vials of acetone were left alone (*Current Biology*, doi.org/brnh).

“It goes to show that there are many ways to get a pollinator,” says Jeremy McNeil at Western University in London, Ontario, Canada.

Emily Benson ■



The secret of youth?

Young ovaries rejuvenate body

Jessica Hamzelou

COULD this be the next extreme anti-ageing fad? Swapping an older mouse's ovaries for young ones seems to reverse the effects of ageing on the immune system and metabolism of female mice, making them live longer.

As we age, our metabolism slows and our immune system runs out of steam. Older people are more likely than the young to have severe cold and flu symptoms, probably because they have fewer fresh immune cells left. And a slower metabolism means that glucose stays in the bloodstream for longer after you eat. Over time, high blood sugar levels can damage organs.

But experiments in mice suggest that transplanting organs from a younger individual could reverse these changes. Jeffrey Mason at Utah State University in Logan removed the ovaries of 10 12-month-old mice that had gone through oestropause, a transition similar to the human menopause.

He replaced these with ovaries taken from 60-day-old mice – roughly equivalent to people in their early 20s in terms of ageing.

In the immune system, the number of naive T-cells that respond to new infections tends to decline with age, and had already fallen in the older mice before surgery. But, overall, between the

“It changes how we think of ovaries in ageing. It may be a fantastic way to increase health”

ages of 6 and 16 months, the number of naive cells in these mice rose by 67 per cent. Cell counts fell by 80 per cent in untreated mice over the same period.

To test metabolism, Mason injected mice with glucose and measured how long it took for their blood sugar levels to return to normal. The mice with young ovaries removed glucose from their blood faster than untreated mice, says Mason, who will present his work at the American

Society for Reproductive Medicine conference in Salt Lake City, Utah, this month.

His team has previously shown that mice given young ovaries in middle age live about 40 per cent longer than their peers, and have healthier looking hearts. “It changes the way we think about ovaries in ageing,” says Mason.

How young ovaries exert these benefits remains a mystery. One theory is that the hormones produced by the eggs inside the ovaries are responsible. But when Mason killed all the eggs inside young ovaries before transplanting them into another set of older mice, he still saw the same benefits. Mason thinks another kind of cell inside the ovary is responsible for the rejuvenation.

Could young ovaries provide anti-ageing benefits for older women, too? Receiving an organ from another person can come with a lifetime prescription of drugs to stop the immune system from rejecting the new tissue. But it could be possible to freeze a person's own ovarian tissue in youth and reimplant it later in life. “It may be a fantastic way to increase health, we just don't know,” says Mason.

Some women already go through a process like this – mostly to restore fertility after cancer treatment – and there is interest in using frozen ovarian tissue to delay the menopause.

But William Ledger at the University of New South Wales in Randwick, Australia, doesn't think these pieces of tissue will last long enough to provide enduring health benefits. “Usually there is ovulation for only a few months, if at all, so any benefit is likely to be short-lived,” he says.

“It's best to be born with an identical twin who is able to share tissues and organs with you,” says Ledger. “But few of us are blessed in this way and, even if we were, it would be difficult to convince twin one to donate to twin two for such specious reasons.” ■

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Transition aligns identity and body

How trans brains sense their bodies

Helen Thomson

DIFFERENCES in the brain's response to touch may explain why transgender people often feel at odds with their anatomy. Information from studies that show this may one day help doctors better help children who identify as trans.

Many trans people feel that parts of their body don't fit with their gender identity. Those who have surgery to change their anatomy overwhelmingly say they feel more like themselves afterwards.

To see if the way the brain processes body image underlies feelings of body incongruity in trans individuals, Laura Case at the University of California, San Diego, and her colleagues recruited eight volunteers who were anatomically female but identified as male and strongly desired a male anatomy. Eight biologically female people who

identify as women were also recruited as a control group.

Participants were tapped on the hand or the breast while their brain activity was monitored using magnetoencephalography. Each person's brain was then imaged using MRI, and the team combined this information to get a clearer picture of the neural response to the tapping.

They found that, in both groups, stimulation of the hand and breast caused areas of the secondary somatosensory cortex to buzz with activity – unsurprising, as this part of the brain is involved in the conscious awareness of touch.

But in the trans group, the activity in this area was significantly lower when their breast was touched compared with their hand (*Archives of Sexual Behaviour*, doi.org/brnj).

There was also less activity in an area called the supramarginal gyrus. This has been implicated in the ability to attribute a sense of

“this belongs to me” to our body parts. For example, stimulating an area close to the supramarginal gyrus can elicit out-of-body experiences. The reduced activity in this area seen in the trans volunteers when the breast is touched suggests that the brain may not treat the breast as strongly belonging to the “self”, says Case.

It is difficult to tell whether these brain differences are innate causes of feelings of discomfort towards gendered body parts, or whether a trans person's aversion

“We hope our experiment shows how important physical transition is to many trans individuals”

to a body part could have caused changes like these to occur in the brain over time.

“[Our experiment] doesn't tell us why these differences exist, but we hope it adds to the medical understanding of gender identity and the importance that physical transition has to many individuals,” says Case.

Studying children before and during their experiences of gender mismatch may help

untangle this, but would be difficult to do, says Case – not least because these body parts are typically private areas, and children may not be very articulate about their gender identity.

Case's study is one of several that have identified neural differences in trans people. For instance, a previous study discovered significant differences between male and female brains in four regions of white matter – and that female-to-male trans individuals who hadn't had sex reassignment surgery had white matter in these regions that more closely resembled a male brain.

Based on results like these, Case and her colleagues hypothesise that some female-to-male trans individuals may have an internal body representation that is closer to being anatomically male than female. If this is the case, it would mean that when their breast is touched, it is compared with an internal representation that has no female breasts. This mismatch could mean that the sensation isn't as well integrated into a person's sense of feeling, leading to a reduced sense of ownership for that part of the body.

Children as young as 2 can express a strong desire to have body parts of the opposite sex, and it is harder to transition after puberty. But these feelings persist in only around 27 per cent by the time they reach adolescence, making it hard for doctors and psychologists to decide whether to give children drugs that delay puberty, or that cause changes that will make it easier to transition later on. Brain activity may help inform these decisions.

However, although Case's study is interesting, we still don't have enough information to identify trans and non-trans brains at the individual level, says Ivanka Berglund at the Karolinska Institute in Stockholm, Sweden. As a result, it isn't yet possible to use scans to identify whether a child is trans or not, she says. ■



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Moon has hundreds more craters than we thought

BRACE for impact. The latest count of the moon's craters turned up 33 per cent more than predicted.

Small meteors regularly hit the moon and Earth. On Earth, they usually burn up in the atmosphere, or land in uninhabited areas. But on the moon they constantly form craters and impact basins, churning up its surface. Only recently have we begun to distinguish new craters amid the moon's already-battered surface.

Emerson Speyerer and colleagues at Arizona State University compared 14,000 pictures of the same place taken on different days by the high-resolution camera on

board the Lunar Reconnaissance Orbiter. They counted 222 new impact craters more than 10 metres wide. The largest is 43 metres in diameter.

The team also found 47,000 new "splotches", which occur when crater debris scatters across vast distances on the airless moon. These were up to 30 kilometres away from the initial impact, suggesting lunar dust and rock can travel great distances after being kicked up (*Nature*, DOI: 10.1038/nature19829).

This dust-up could pose hazards to future lunar settlements. "If you are an astronaut sitting on the surface, you don't necessarily have to worry about being directly hit by a meteorite, but you would have to worry about all these secondaries that are coming from kilometres and kilometres away," says Speyerer.

No more info on exoplanet next door

THE hunt to learn more about our nearest exoplanet, Earth-like Proxima b, has come up empty-handed. If the planet ever passes between its star and us, we could rapidly learn a lot about it – but it seems unlikely to happen.

David Kipping at Columbia University in New York City and his colleagues spent more than 40 days in 2014 and 2015 searching for transits of planets orbiting

Proxima b's host star, using Canada's MOST Space Telescope.

When the European Southern Observatory discovered Proxima b in 2016 from its star's periodic wobble, the team narrowed their search, waiting for Proxima b to pass in front of the star. Capturing this event can yield data about a planet's atmosphere and surface.

The star's faintness and constant flares made observations difficult.

Also, the geometry of the planet's orbit meant the chance of a transit was calculated at 1.5 per cent. Despite one candidate signal, the team has now concluded Proxima b probably doesn't transit its star (arxiv.org/abs/1609.08718).

Without a transit, we must observe the exoplanet directly to learn more. The James Webb Space Telescope, set to launch in 2018, will supply some information, but more detail is likely to be years or even decades away.

Brain cells glimpsed while on the move

THIS is how minds are made. For months after birth, armies of neurons migrate through the brain, and now researchers have had the best look at this process yet.

Eric Huang at the University of California, San Francisco, and his team worked with donated brain tissue from infants who had died of causes unrelated to their brains. They kept thin slices of brain alive in a dish for up to two days and, using a microscope, were able to see cells continuing to migrate.

MRI scans showed large numbers of neurons moving into the frontal lobes, which are responsible for higher thought processes (*Science*, doi.org/brjz). "They form this very beautiful arc," says Huang.

The brains of recently born babies had the most moving neurons, with numbers largely tailing off by about 5 months of age.

Fishing spider ties and eats crayfish

A FISHING spider has been found feasting on a young crayfish it had tied up beside a creek in Virginia.

"We were all pretty excited when we stumbled across the event," says Zachary Loughman at West Liberty University in West Virginia. No one has reported this behaviour in the wild, and similar records in captivity are rare.

The large female striped fishing spider had devoured most of the young spiny stream crayfish's abdomen when discovered, and had used silk threads to anchor the animal under a rock in a small pool – most likely after killing it (*Southeastern Naturalist*, doi.org/brjs). But such predation is probably too rare to further threaten crayfish, some of which are endangered.

Eerie orange crocs gorge on cave bats

CAVES can be scary, and they get a lot scarier when filled with crocodiles. "I was crawling through the cave and suddenly there were two red eyes," says explorer Olivier Testa. "It was frightening!" He was part of an expedition into Gabon's Abanda caves following up a tip about dwarf crocodiles living there.

While crocs sometimes retreat underground during droughts, this is the first population known to take up long-term residence in caves.

They soon realised why the crocs were there. A bounty of snacks was falling into the water or lining up to be plucked off the cave walls. "You walk in and there are just bats and crickets everywhere," says the team's crocodile expert, Matthew Shirley of the Rare Species Conservatory Foundation in Loxahatchee, Florida. "The crocodiles are pretty good hunters, but even if they didn't have to pull bats off the walls, there are some falling to the floor all the time."

Perhaps because of their steady diet, the crocs seem in better condition than their forest counterparts (*African Journal of Ecology*, doi.org/brjr).

Another curiosity is that some dark-coloured males were orange. "The urea in bat guano makes the water very basic," Shirley says. "Eventually that will erode away the skin and change its colour."



OLIVIER TESTA

Migrant starlings draw hordes to their food bonanzas

LET the party begin. Every year, crowds of animals gather to enjoy feasts hosted by colonies of starlings.

Metallic starlings (*Aplonis metallica*) migrate from New Guinea to the tropical rainforests of north-east Australia, where they stay from November to April. The birds return to the same patch each season, with up to 1000 nesting in any one tree.

The areas underneath their nesting sites become some of the world's most diverse wildlife hotspots. Mammals, reptiles,

amphibians and other birds congregate to feed on seeds scattered by the starlings. Bird droppings enrich the soil, boosting insect populations and root growth, which provide additional food sources.

An eight-year study of 27 starling colony trees on Cape York Peninsula in Queensland found that they attracted 42 species during the nesting season. Many species were 100 to 1000 times more abundant under nesting trees than trees elsewhere (*PLoS One*, doi.org/brjt).

"The hotspots are spectacular," says Daniel Natusch at the University of Sydney, who led the study. "It is uncommon to have a single resource that attracts such a diverse assemblage of species."

Other bird colonies attract animals – penguins draw predatory seals, whales and sharks, for example. But the species pulled in by Australia's starling colonies are unrivalled in number and diversity, including wallabies, bandicoots, brush-turkeys, cockatoos and brown tree snakes.

Thirsty throats drink more easily

THIS isn't hard to swallow. Our body can influence the amount of fluid we put in our body by making it easier or more difficult to gulp down drinks.

A study by Michael Farrell at Monash University in Melbourne, Australia, and his colleagues has found that swallowing is effortless when we are dehydrated, but more difficult if we have drunk plenty, putting us off from drinking any more.

The team asked volunteers to rate the sensation of taking a sip of water when they were mildly dehydrated, as well as after they had been asked to drink as much water as they were comfortably able. Their ratings for how much effort it took to swallow rose from one out of 10, to about five.

Brain scans showed that when people were overhydrated, swallowing was linked to more activity in some parts of the brain that are responsible for conscious thought processes (*PNAS*, DOI: 10.1073/pnas.1613929113).

"It shows we have very subtle mechanisms for regulating the amount we drink," says Farrell. "If left to your own devices, you will drink the requisite amount of water to maintain balance."



MARKUS REIGELS/GETTY

No splashing in the operating room

SOMETIMES, you don't want to make a splash. A study shows how to stop droplets of hazardous liquids or pathogenic fluids flying through the air: line the lab bench or surgeon's instrument tray with soft materials.

When a drop of ethanol strikes a hard acrylic surface, tiny jets form where it hits, and these disintegrate into smaller droplets that can be blasted into the air.

But when a team led by Alfonso Castrejón-Pita at the University of Oxford swapped the acrylic for soft silicone, the surface deformed on impact, absorbing energy from the

jets. This meant they didn't break away from the drop, which stayed intact and formed a tiny puddle.

To stop splatter from a faster-falling drop, you just need an even softer surface (arxiv.org/abs/1511.06212).

Splashless surfaces could also contain salmonella-infected raw chicken juices in kitchens and keep toilets clean, says Castrejón-Pita.

Previously, we knew splashing could be lessened by moving the surface sideways as a drop hits, which also cuts impact energy, or by lowering the air pressure.

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Introduction by **Professor Stephen Hawking**

**New
Scientist**



Virtually there

Reality check

PlayStation VR has joined the wave of new virtual reality gear, but will it ever have mainstream appeal? **Hal Hodson** investigates

IF YOU believe the hype, 2016 is the year of virtual reality. Long thought to be a technological dead end, VR began its comeback in 2012, when an upstart called the Oculus Rift took the internet by storm with its promises of a fully immersive environment.

Tech giants scrambled to make their own headsets – Sony’s PlayStation VR, released this week, is the latest. Now that these devices are finally on the market, we’re starting to figure out how they might fit into our lives.

Facebook, which bought Oculus for \$2 billion in 2014, has anointed VR as the technology that will

supersede smartphones as the primary medium for digital life. “We are here to make VR the next major computing platform,” said CEO Mark Zuckerberg at an Oculus conference last week. But it seems the general public isn’t buying into this brave new world – sales of high-end goggles are tiny and hardly growing. Could it be that while people are happy to paw at a screen, they don’t want one inches from their eyeballs?

VR has burned out before. In the 1990s, bulky VR booths started showing up in cinemas, and Nintendo launched its Virtual Boy headset in 1995. But the bubble

quickly burst as people found the creaking tech to be a lacklustre experience, and the Virtual Boy was discontinued after a year of disappointing sales (see chart).

This time is different, says Tobias Höllerer at the University of California, Santa Barbara. “For the first time, all the major players are invested in the field – Google, Apple, Microsoft, Facebook.”

Unlike in the 1990s, the gear really works, and as of this year,

“VR has burned out before - in the 1990s people found the creaking tech to be a lacklustre experience”

consumers can buy it. Modern VR runs the gamut from cheap and cheerful viewers to expensive hardware dedicated to delivering true immersion.

Purpose-made headsets are on the top end of this spectrum, with high-quality optical components and sensors that track the wearer’s movements and replicate them in the virtual environment. The HTC Vive and Facebook’s Oculus Rift are the two main players in this full-blown experience – which enthusiasts call “real” VR. They cost about £600, plus another £900 for a computer with enough power to drive the graphics.

The opposite end of the spectrum is a smartphone strapped to your face. These viewers can be very basic: Google has shipped millions of units called Cardboard, which is just two plastic lenses in a cardboard housing for the phone, sold cheap or even given away.

Others, like Samsung's Gear VR and Google's Daydream, cost less than £100 and integrate some of the features of pricier headsets, like head tracking, providing reasonable VR experiences when paired with a top phone.

But people aren't using their phones to explore Zuckerberg's virtual future. They're just watching fancy videos.

Niche thing

It's a growing market for directors like Sebastian Hagemeister. Based in London, he flies all over the world filming 360-degree video, promos and adverts designed to be viewed in virtual reality. A whole industry has sprung up making expensive content for platforms that most of us have never used and are only just starting to get our hands on.

For that reason, Hagemeister says most of his videos are viewed on normal computer screens through Facebook or YouTube.

"I don't have any stats, but I'm pretty sure that people watching these on the headsets are very much a minority at the moment, and will be for quite some time," says Hagemeister. "It's quite a geeky niche thing."

Still, at the bottom end of the market, VR viewer sales are on the up. "In the second quarter of 2016 over a million Cardboard units shipped in China," says Tom Mainelli at IDC, a market research company in Framingham, Massachusetts. Samsung's Gear VR is bundled with the company's latest smartphone, and Facebook says 1 million people have used the device to access its content.

Google also plans to bundle its Daydream viewer with every

new Pixel phone it sells – a good strategy, says Mainelli. "VR is not going to be as big as smartphones, but by attaching itself to smartphones you can get to a big number of people."

In contrast, sales of dedicated headsets are flatlining. Neither HTC nor Facebook are open about the number they've sold, although Zuckerberg did admit to a "slow start" for the Oculus Rift.

That's in line with data from game marketplace Steam, which conducts a monthly survey of its users' hardware. Figures for VR headsets have remained effectively flat for months, with 0.31 per cent of Steam users reporting the hardware in September. It's perhaps no surprise, given that VR lacks a "killer app" to drive hardware sales, as *Wii Sports* did for the Wii.

This week's release of the PlayStation headset is the last ray of light for "full" VR. Somewhere between the impressive capabilities of Vive and Oculus, and weaker phone-powered VR, Sony's headset will run off the PlayStation 4. With millions of consoles out there, it can plug into a ready-made market that neither Oculus nor HTC has.

Even if full-blown VR does go

LIFE, OVERLAID

This year saw a craze for a new kind of reality – *Pokémon Go*, the first augmented reality (AR) application to achieve mass appeal. The smartphone app, which lets players hunt and catch creatures overlaid on an image of the physical world, has been downloaded more than 500 million times.

Pokémon Go is the most basic AR possible, because it doesn't place critters in the real environment in a particularly sophisticated way. But for many people, hunting Pokémon has been their first example of engaging with a world that interweaves the physical and digital.

Industry watchers such as Tom Mainelli of IDC, a market research

The future isn't here yet

First-year sales figures for VR headsets suggest they aren't being adopted as enthusiastically as other consumer technology



mainstream, how will it be used? Hollerer suggests that homes may have an alcove for occasional VR use. Live sports could also drive adoption, if broadcasters get on board. "Think about the ability to be court-side in a basketball game," says Mainelli. "You can see how advertisers would see the upside."

Ultimately though, VR's inherent effect of shutting out the world limits its potential. This has led industry observers to suggest that augmented reality, rather than virtual reality, is a more legitimate place to look for Zuckerberg's "next platform".

Instead of immersing the viewer in a digital world, augmented reality overlays the physical world with digital information. "I happen to think

that AR is the real game changer and is going to have a much bigger impact on consumers and business," says Mainelli (see "Life, overlaid", below left).

Zuckerberg may have reached the same conclusion – at the conference last week he pointed the way to a future, a mere 10 or

"We wouldn't have thought 10 years ago that people would be walking around staring at small screens"

15 years away, where simple glasses can deliver both immersive VR and AR experiences.

Makers of these devices are all essentially second-guessing the same thing – what comes next in society's ongoing shift towards merging digital information from screens with our daily lives. Bulky headsets may not win us over, but it seems inevitable that we will keep reducing the distance between us and the digital worlds we increasingly inhabit.

"We wouldn't have thought 10 years ago that people would be walking around staring at small screens while they're walking," says Höllerer. "But they do, because the benefits are there."

For VR to work, it will have to get cheaper and easier to use, making the tech of the Oculus and Vive more accessible to the masses. The technology will also need to offer tangible benefits, not merely port functions from old screens to new. Whether that is possible before the bubble bursts again remains to be seen. ■

A tricky relationship

Why do we find it so hard to embrace the idea of a peaceful robot destiny, wonders **Kate Devlin**, who studies human-robot interaction

WILL we ever learn to love our robot future? With rapid advances in this technology – sex robots, companion bots and more are said to be around the corner – it seems a reasonable question to ask, especially given almost every fictional account of that future is still a dark “them and us” tale.

With the reboot of SF yarns such as *Westworld* and *Humans* on television, androids – the class of robots designed to be utterly human-like – are once again capturing our imaginations.

It was in 1970 that Masahiro Mori at the Tokyo Institute of Technology predicted that as we try to make robots more human, we would reach a point where we were disturbed and repulsed by them as they became almost, but not quite, human.

He labelled this effect the “uncanny valley” – hypothesising that when technology improved



and robots became truly human-like, then we would once again feel comfortable with them. The robots in *Westworld* look just like us. They have crossed the valley (of course they have, these are actors).

According to Mori's work, which has been tested and validated, we should be unthreatened. But in these fictions, and many others, robots are still portrayed as other and treated as such. For example, in scenes with sex robots – surely an ultimate test of human-robot relations – *Westworld* guests use that otherness as an excuse to unleash their worst natures.

In reality we have a relationship with technology that few of us can avoid. Unknowingly or not, we bond with digital products. Think of smartphones – we are fiercely protective of them; they are too intimate for us to hand over to just anyone to use.

Why then, when our children

Seeds of change

India's bid to grow genetically modified food crops is on a knife edge, says **TV Padma**

IT IS crunch time for India's hope of growing genetically modified food crops. Will it succumb to a European-style backlash against the technology, or open the door to varieties supporters say are vital in a nation grappling with malnutrition, a rapidly growing population and climate change?

Waiting in the wings for final

government clearance is modified mustard, developed by scientists at the University of Delhi and reported to raise yields by 25 per cent. It would cut India's reliance on costly edible oil imports, and it uses proven technology: the same genes used to engineer the crop are already in GM rapeseed oil in Canada, the US and Australia.

India's Genetic Engineering Approval Committee (GEAC) has released its biosafety review, finding no “measurable risk, for sustained use of the technology”.

But battle lines are hardening between biotechnologists and environmentalists, farmers' lobbies, and right-wing groups that support the government.

India has been here once before. The GEAC cleared a GM aubergine in 2009, but after input from the public, environmentalists and

farmers, its environment minister imposed a “two-year moratorium”, which is still in force.

This time there is also a case in India's Supreme Court seeking a ban on all such crops. Pushpa Bhargava, a GM opponent and head of a technical committee appointed by the court, argues that the GEAC has not released sufficient data on the mustard.

The wider backlash may reflect a failure to make data public before clearing India's first GM crop – Bt cotton – and over-hyping the tech's potential. The bollworm pest went on to become resistant to first-generation GM cotton.

Most research on GM food

“The backlash may reflect a failure to make data public before clearing India's first GM crop – Bt cotton”

are born digital natives and we spend our days using technology, do we still endlessly portray lifelike robots as a step too far?

The answer may lie in our perception of control. While we already embrace AI through apps such as Siri, we have the sense that we are in charge; that they are inanimate and under our command. Not so androids.

A wealth of stories spanning millennia have warned us of the dangers of human-like machines, from Talos the Cretan bronze giant attacking the Argonauts, to James Cameron's *Terminator*. We fear the dystopian potential – and we aren't always wrong to do so. The singularity might not be upon us yet, but there are machines on the battlefield and drones in the air that already threaten lives.

We have long been warned about artificial life, a trope that seeps into our everyday existence. Take a tendency to distrust disruptive technology and mix it with the potential for autonomous AI in human form, and it's no wonder we still prefer to make war, not love, with the robots. ■

Kate Devlin lectures in the computing department of Goldsmiths, University of London. The Second International Congress on Love and Sex With Robots takes place there in December

crops is not contentious, but the claim the technology is a panacea for India's malnutrition problems is. To say they can be solved with, say, vitamin A-fortified crops is doubtful. India's surplus grains rot, while government-subsidised food distribution and nutrition programmes fail to reach those who desperately need them.

Yes, the GM mustard verdict matters as a test of evidence over misinformation, and of India's fledgling efforts to gain public trust via greater transparency. As an effective fix for its endemic problems, it matters much less. ■

TV Padma is a science writer in Delhi

INSIGHT UK fracking



Protests have been ignored

UK has no good reason to approve fracking

Michael Le Page

IT SEEMS the new UK government under prime minister Theresa May is determined to "go all out" for fracking. Last week it approved four exploratory wells in Lancashire, overriding a local decision against drilling because of the noise and traffic it would create. It's a bad idea for many reasons.

For starters, we already have more fossil fuel than we can afford to burn. If we are serious about tackling climate change, we have to leave most reserves underground. A recent study concluded that even if we stopped burning coal right now, there is enough oil and gas in currently exploited reserves to take the world past 1.5°C of warming – the aspirational limit set by the Paris climate agreement, which comes into force in November. That's just the reserves we are already tapping, not those discovered but not yet exploited.

Countries that continue to encourage further exploration for fossil fuels, as this UK decision does, either don't understand the implications of the Paris agreement or worse, don't care.

The government's published decision says issues such as how shale gas relates to the Paris agreement are a matter for future policy decisions, not this specific local planning decision. In other words, it chose to ignore the inconvenient facts.

But it goes on to say "shale gas exploration... could help to achieve lower carbon emissions" and "the projects represent a positive contribution towards the reduction of carbon". Really?

It's true that if shale gas were used to replace coal, it could reduce emissions and act as a "bridge fuel"

"If we are serious about tackling climate change, we have to leave most reserves underground"

to renewable energy. But shale gas is not going to replace coal in the UK, because the country is on course to meet its pledge to phase out coal by 2025, well before shale gas production begins in earnest.

Coal use has already fallen by two-thirds this year alone compared with the same period last year. In fact, over

the summer the country got more of its electricity from solar than from coal.

What's more, while the independent body that advises the UK government, the Committee on Climate Change, has said that shale gas could act a bridge fuel, it also said fracking would bust the UK's emissions budget unless several conditions were met. One is that there must be tight controls to limit methane leakage from fracking wells – controls that are not in place.

So as things stand, fracking will not help achieve lower UK emissions. The government is ignoring the truth. And it is doing so to try to help create an industry that has no future.

Shale gas will have to be phased out after 2030, the Committee on Climate Change has also concluded. Why invest in infrastructure that will have to be abandoned, and train people to do jobs that will be cut?

There are other reasons why fracking is a bad idea. For instance, there is a risk of water supplies being contaminated by fracking wastes, as has occurred in the US. Former prime minister David Cameron promised that tighter regulation would prevent this ever happening in the UK, but it later emerged he had lobbied to prevent the EU imposing strict regulations.

Last but not least, fracking might not even be economically viable if gas prices remain as low as they are. So why is the government so gung-ho for fracking? If it has good reasons, it's not sharing them with us. ■

Hello creepy

Connected toys are raising hackles over children's privacy. What might they mean for play itself, wonders **Aviva Rutkin**

SMART toys are with us: dolls that respond to kids' questions and movements; an imitation smartwatch that chats with other devices over Bluetooth; puzzles that talk to the puzzler. A smart toy might even live in a smart home – like the Barbie Hello Dreamhouse, a connected house for the iconic doll.

These toys have the potential to enhance play, but also the capacity to spy. Privacy activists object to them on the grounds that children cannot grasp the implications of their data being gathered. Psychologists suggest that the toys don't offer any clear benefits over their "dumb" counterparts.

It's not the first time Hello Barbie has been in trouble. Perhaps 2015's most controversial toy, this doll could hold court on a wide range of topics – from fashion and family to paddleboarding. "Did you know that butterflies live

everywhere in the world except Antarctica?" she might say, before confessing to "daydreaming about cupcakes".

The problem wasn't her words, but that kids could talk back. When a child pressed her belt buckle, Barbie's microphone sent their words to Mattel's servers for analysis by speech recognition algorithms, ostensibly to settle on a suitable reply.

Soon, details emerged about how those recordings were stored and some of the third parties they were being shared with. A backlash ensued. The Campaign for a Commercial-Free Childhood, a non-profit in Boston, launched the social media campaign #HellNoBarbie, urging parents not to buy the doll. "We were immediately concerned about the idea of a doll that was recording and capturing children's conversations," says Josh Golin, CCFC's executive

director. "It just struck us as such an invasion of children's privacy."

There's nothing illegal about how Hello Barbie works, but you can adhere to every US law and still violate a kid's privacy. Children lack the experience to grasp that whatever they tell a toy is accessible to an unseen team of engineers – or their parents.

"You can adhere to laws and still violate privacy - kids don't grasp that engineers can access what they say"

Or hackers. Toys, and the data their makers collect, are vulnerable to attack online. Last year, the Hong Kong-based toy-maker VTech leaked photos, download histories and chat logs of its 6.4 million young users. Baby monitors have been hacked, too, allowing strangers to peer in at children in their beds and even talk to them.

To be sure, not everyone shares the privacy concerns. "[Hello Barbie] is just as risky as Siri and I've told Siri some pretty odd things," wrote one unrepentant five-star reviewer. In a home full of connected devices, where do you draw the line? Why is it different for a child to talk to Siri, or Alexa, or any of the other crop of new digital assistants?

Worse still, for all the invasion of privacy that these chatting skills entail, Hello Barbie may not even be a very good toy: Golin says the best toys are "90 per cent kid, 10 per cent toy," with play fuelled largely by the child's imagination.

That's in line with what research has been telling us for decades about the evolutionary and cognitive purposes of play. Pretend play, in particular, is how kids learn complicated skills like considering various solutions to problems, the use of symbols, even self-regulation.

While toys can be part of that, products like Hello Barbie coax kids into providing rote answers to preprogrammed questions, rather than imagining anything. "Play ends up being completely driven by the script in the algorithm," Golin says.

But maybe smart toys offer a different kind of educational opportunity: they could start teaching kids the digital literacy skills they will need later in life.

Perhaps we need a different kind of smart toy – like one of the many robots that can teach even the youngest kids to code. They might even let children engage in the hacking equivalent of that time-honoured ritual of Barbie owners around the world: ripping her head off. ■



The smarter dolls' house

Silent squeals make TV interactive

HEAR that high-pitched ringing? No, me neither. But such sounds at low volume can now be used to deliver bonus television content to your cellphone or tablet.

"Imagine that you're watching a travel programme and your phone instantly receives the exact location, booking details and nearby attractions of the place you see," says Tae Hyun Kim of Soundlly in Seoul, South Korea which developed the technology.

The system uses your TV's speakers to play data-filled tones alongside whatever you are watching. You won't notice a difference, but the microphone on your smartphone will, picking up additional content streamed alongside the main event. "This can make television interactive," says Tae.

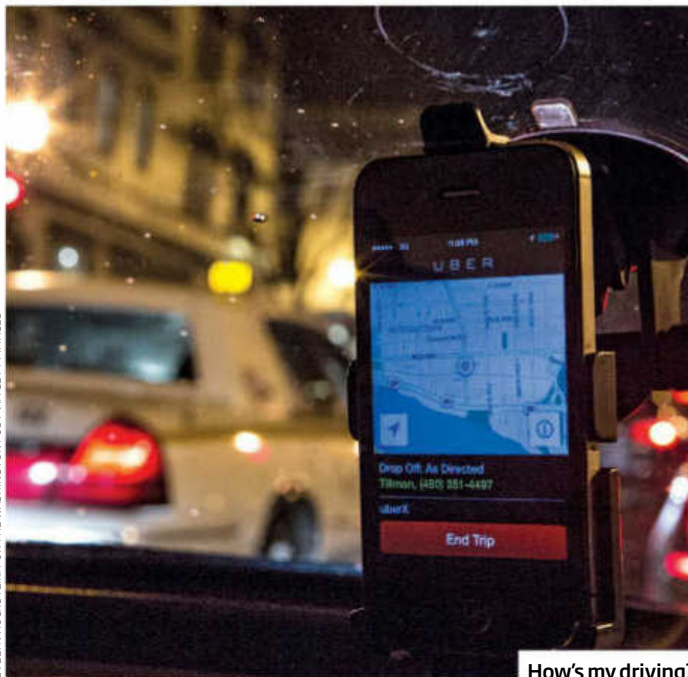
This use of ultrasound is already possible, but the volume levels break broadcasting rules and can irritate young people or animals. "The real advantage of our system is that its noise level is the same as a quiet library," says Tae.

Soundlly's focus is currently on second screens such as your phone or tablet, but the technology could be used to send data between any two devices that have speakers and microphones, says Mu Mu at the University of Northampton, UK. "Using ultrasound, devices can literally talk to each other." Timothy Revell ■



From one screen to another

EVELYN HOCKSTEIN/FOR THE WASHINGTON POST VIA GETTY IMAGES



How's my driving?

Help, my boss is an algorithm

"Uber, your ratings are a complete joke," complained a driver recently on UberPeople, an online forum for workers using the popular ride-sharing service.

Their post inspired a heap of comments from drivers upset about their own unexplained low scores. Others groaned – whinging about the rating system was old news. "Does it suck? Yes. Is it unfair? Yes," wrote one. "Just keep being diligent and you'll be fine. And yes, let's stop talking about this now."

But as well as causing annoyance to drivers, a study suggests the ratings mechanism could allow customer's biases to creep into the system, as has been seen with other "gig economy" platforms like Airbnb.

To better understand how customer ratings affect Uber drivers, a team led by technology ethnographer Alex Rosenblat at the Data and Society research institute in New York scoured

months of forum posts and interviewed drivers. They presented the work at the Internet, Politics & Policy conference at the University of Oxford last month.

The trouble is that many passengers may not understand how important the ratings are to drivers, or which criteria Uber expects users to consider, says Rosenblat. People might think that a four-star rating is good, for example. But as drivers risk being kicked off the platform if their average score drops below 4.6, anything under the maximum five stars constitutes a failing grade.

The rating system could also open the back door to discrimination against drivers, say the team. They acknowledge that it is hard to determine the role prejudice plays in Uber ratings, if any, without access to the company's internal data. But studies of other online services, such as Craigslist and Airbnb,

have already shown that people of colour, for example, often experience hidden bias from users. One study found that people with names perceived as African-American are 16 per cent less likely to be accepted as Airbnb

"Many passengers may not understand how important the ratings they give to drivers"

guests than those with white-sounding names, for example.

As a result, the study authors write: "Consumer-sourced ratings of this sort are highly likely to be influenced by bias on the basis of factors like race or ethnicity."

Watching what Uber does is important, because the firm sets the tone for how other gig economy companies might choose to manage their workers. Uber has fought to describe itself as a technological platform, not a taxi company, meaning that drivers are considered independent contractors rather than employees. Using software to keep tabs on so many scattered workers from afar may introduce a new crop of workplace problems.

Rosenblat's team hopes Uber will keep an eye out for any problematic patterns regarding bias against drivers. In the meantime, they offer a few technological solutions, such as using smartphone sensors or human evaluators to validate customer ratings. Alternatively, ratings could be unlinked from employment decisions entirely, replaced with an internal evaluation system, or perhaps used just to rank the drivers.

"I think decoupling ratings from employment makes a lot of sense," says Rosenblat. "You could also go back to the more old-fashioned way where you use ratings as a red flag and then send a human evaluator to check in."

Uber had not responded to a request for comment as *New Scientist* went to press.

Aviva Rutkin ■

AI 'finprinting' IDs sharks

A fin-tracking tool keeps tabs on sharks. **Chris Baraniuk** dives in

GREAT white sharks migrate over huge distances, making it tricky to track individuals through the seasons. Now, a project hopes to automate their identification from photographs of their fins.

The technique, known as "finprinting", uses the unique contours of a shark's dorsal fin as a biometric – rather like a human fingerprint or iris. Researchers have scrutinised fins to identify sharks for years, sometimes using software to help, but the new project aims to make the whole process automatic.

The system, developed by Ben Hughes and Tilo Burghardt at the University of Bristol in the UK, has been trained on 240 photographs of shark fins.

In tests, the software was able to analyse a picture of a shark fin and identify, with an accuracy of

81 per cent, whether it belonged to a known individual or not (arxiv.org/abs/1609.06323).

The approach should help researchers keep tabs on noteworthy behaviour in shark migrations. In 2005, for instance, Michael Scholl, then at the White Shark Trust, and his colleagues reported an astonishing finding: a satellite tag on a great white nicknamed Nicole showed that she had travelled from South Africa to Australia and back within nine months.

This was an insight into the wanderlust of the species – but after that, sightings of the shark ran cold. The new system might one day help spot her.

"It could be a fantastic tool," says Greg Skomal, a fisheries scientist at the Executive Office of Energy and Environmental Affairs

in Boston, Massachusetts.

Skomal is creating a catalogue of the growing population of great whites observed off the east coast of the US, an area popular with divers and windsurfers. His team spends "hundreds, if not thousands" of hours doing manual photo identification each year.

Hughes hopes to have the tool in the hands of researchers such as Skomal by the end of March 2017, using photos collected by

"The system could be fed with photographs taken by people who go shark watching or cage diving"

scientists in the field. The plan is to later feed the AI system photographs contributed by members of the public who go shark watching or cage diving. That way, a far greater number of identifications can be recorded.

Automatic identification has already been successfully tried out on other species, such as zebras, by scientists working on Wildbook, the wildlife-data platform where the shark tool will be hosted.

Tools to identify sharks and other animals make it possible to analyse these species' social networks, too, says Tanya Berger-Wolf, a computer scientist at the University of Illinois, Chicago, and co-founder of Wildbook's system.

She says that Hughes and Burghardt's shark-identification tool might need some tweaking before it can be used to identify large numbers of individuals. That would mean training it on a bigger set of photographs.

The tool leads to the possibility that, one day, someone might upload a snap of Nicole's fin. For Scholl, that would be thrilling. "It'd be one of the happiest days of my life," he says. ■

ONE PER CENT



AI takes the tube

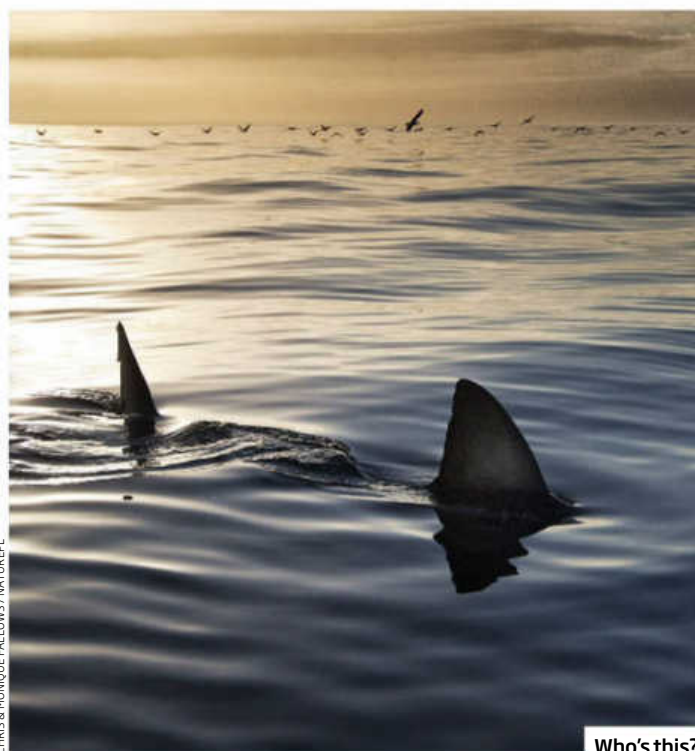
Visitors sometimes have trouble navigating the London Underground system, but an AI trained by Google's DeepMind has learned to plot the best route. A chimera of traditional computers and neural networks, DeepMind is able to tackle tasks that require it to handle sequences, while remembering and reusing what it learns as it goes. This lets it find the shortest route from A to B through London's tangle of stations (*Nature*, DOI: 10.1038/nature20101).

"admin/123456"

One of 68 default login details used by a piece of software called Mirai to hijack poorly secured devices. The hacker who released the code for Mirai last week claimed they could take control of 380,000 devices with these credentials, using the devices to attack other parts of the internet with a flood of traffic.

Baby-bot melts hearts

Not a fan of babies? A cute teacup-sized robot called Kirobo Mini, which was released by Toyota last week, might just soften you up. "He wobbles a bit, and this is meant to emulate a seated baby," Fuminori Kataoka, Kirobo Mini's chief design engineer, told Reuters. "This vulnerability is meant to invoke an emotional connection."



Who's this?

CHRIS & MONIQUE FALLOWS / NATUREPL

AGE FOTOSTOCK / ALAMY STOCK PHOTO

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Giant from the bog

THE huge antlers and other bones pictured here belong to an extinct Irish elk that once roamed across ice age Europe and parts of Asia and Africa.

It owes its common name to the peat bogs of Ireland, where many well-preserved specimens of its skeleton have been discovered.

Megaloceros giganteus was a Pleistocene era species whose distinctive antlers - which could span more than 3.5 metres - have inspired artists for thousands of years, from the creators of the Lascaux cave paintings to the photographers of today.

Modern studies show that the last members of the species died out about 7700 years ago in Siberia. But when Thomas Molyneux first described it in 1697, the idea that the creature was already extinct fuelled much scientific debate. Some scientists, including Molyneux, thought that living examples of animals known only through their fossilised remains were simply yet to be discovered in uncharted corners of the world. But Charles Darwin and others favoured the extinction explanation, arguing that the Irish elk, which could grow to more than 2 metres tall, would be difficult to miss.

The picture appears among a collection of 200 images by photographer Robert Clark in the book *Evolution: A visual record*, published next week by Phaidon. Emily Benson

Photographer

Robert Clark

robertclark.com

Dead on your feet?

If you're tired all the time, it probably isn't down to lack of sleep, says Emma Young

YOU'RE in bed by 11, having had a busy, productive day. After a full night's sleep you wake up naturally and feel... exhausted.

If this sounds familiar, you're not alone. According to a recent survey of over 20,000 people by researchers at Radboud University in the Netherlands, about 30 per cent of visits to doctors involve complaints about being tired all the time. Some 20 per cent of people in the US report having experienced fatigue intense enough to interfere with living a normal life. This hits us in our pockets, too: workers who are unproductive because of fatigue cost US employers more than \$100 billion a year.

It's perhaps surprising, then, that we are only now beginning to work out what fatigue actually is. Until recently, daytime tiredness was presumed to be nothing more mysterious than simple physical exhaustion or feeling the need to sleep – the US Centers for Disease Control and Prevention estimates that 35 per cent of people are short on sleep. Combine that with the fact that tiredness is subjective and therefore difficult to measure, and that the subject falls somewhere between studies of the body and mind, and it's small wonder fatigue has largely escaped scientific scrutiny.

Since tiredness accompanies so many common diseases, not to mention ordinary ageing, a better understanding of its causes could improve quality of life for pretty much

everybody. A handful of researchers are now trying to figure out the causes, and possible fixes. Although it's early days, a few clues are emerging.

One cause, we might think, is that life is more exhausting than it has ever been. Caught between the competing demands of work and family, not to mention the ever-present buzz of smartphone notifications, it is no surprise so many of us feel as if we are running on empty. Yet this may be a fallacy. According to Anna Katharina Schaffner, a historian at the University of Kent in Canterbury, UK, and author of *Exhaustion: A history*, people through the ages have consistently complained of being worn out, and harked back to the relative calm of simpler times. Over the centuries, fatigue has been blamed on the alignment of the planets, a lack of godliness and even an unconscious desire to die, says Schaffner. "Freud argued that a very strong part of ourselves longs for a state of permanent physical and mental rest," she says.

In the 19th century, a new diagnosis appeared: neurasthenia. The American physician George M. Beard claimed that this condition, supposedly caused by exhaustion of the nervous system, was responsible for physical and mental fatigue as well as irritability, hopelessness, bad teeth, cold feet and dry hair. Beard blamed neurasthenia on the advent of steam power and newfangled inventions such as the telegraph. Women's

education was also considered to be tiring for all concerned, while the advent of the printing press brought an abundance of newspapers and magazines to keep up with. "Beard feared that the modern subject was unable to cope with such chronic sensory overload," says Schaffner.

If modern life isn't to blame, another possibility is that at least some fatigue is down to a lack of sleep. Researchers distinguish between the need for sleep and fatigue, however, considering them to be closely related but subtly different. The good news is that there is a fairly easy way to tell which might be wearing us out: the ➤

20

per cent of road accidents have fatigue as a contributing factor

Source: Department for Transport



sleep latency test. Used widely in sleep clinics, it is based on the idea that if you lie down somewhere quiet during the day and fall asleep within a few minutes, then you are either lacking sleep or potentially suffering from a sleep disorder. If you don't drop off within 15 minutes or so, yet still feel tired, fatigue might be the problem.

So if it's not the same thing as sleepiness, what is fatigue? Mary Harrington, a neuroscientist at Smith College in Northampton, Massachusetts, is one of a handful of researchers looking for a telltale biological signal of fatigue. So far no single marker has emerged that tallies with how tired people say they feel, but "we do have some candidates", she says.

One possibility Harrington is investigating is that daytime fatigue stems from a problem with the circadian clock, which regulates periods of mental alertness through the day and night. This regulation falls to the brain's suprachiasmatic nucleus, which coordinates hormones and



brain activity to ensure that we feel generally alert by day. Under normal circumstances, the SCN orchestrates a peak in alertness at the start of the day, a dip in the early afternoon, and a shift to sleepiness in the evening.

The amount of sleep you get at night has little impact on this cycle, says

15

per cent of Britons suffer from fatigue lasting at least 6 months

Source: *Fatigue Science for Human Health*

Harrington. Instead, how alert you feel depends on the quality of the hormonal and electrical output signals from the SCN. The SCN sets its clock by the amount of light hitting the retina, so that it keeps in line with the solar day. Too little light in the mornings, or too much at night, can disrupt SCN signals, and either can lead to a lethargic day. "I think circadian rhythm disruption is quite common in our society and is getting worse with increased use of light at night," says Harrington.

If you spend the day feeling as if you have never quite woken up properly but are not sleepy at bedtime, a poorly calibrated SCN might be to blame, says Harrington. She suggests trying to spend at least 20 minutes outside every morning and turning off screens by 10 pm to avoid tricking the SCN into staying in daytime mode.

Another way to reset the SCN is to exercise, Harrington suggests. Several studies have linked exercise – whether a single bout or regular physical

MISSING SOMETHING?

Pharmacy shelves are groaning with supplements claimed to "fight fatigue" and help you "re-energise". So is there any evidence that boosting some magic ingredient will endow us with greater vitality?

IRON

Too little iron certainly can lead to fatigue. And while only 3 per cent of men and 8 per cent of women are diagnosed with clinical iron-deficient anaemia, there is some evidence that iron supplements may still provide an energy boost for the rest. One group of non-anaemic women who experienced "considerable fatigue" had their fatigue score nearly halve after 12 weeks on iron tablets. Those on a placebo reported a 29 per cent drop, however, so the true effect is hard to gauge. Nevertheless, we need to understand the importance of iron deficiency in fatigue – even where there is no anaemia, according to Jill Waalen, an epidemiologist at the Scripps Research Institute in La Jolla, California.

B VITAMINS

B vitamins are also commonly touted as a magic bullet to boost energy, but there is little evidence that supplements will make any difference unless you are deficient. David Kennedy, who researches the impacts of nutrients on brain function at Northumbria University in Newcastle Upon Tyne, UK, says that while most people who eat a healthy

diet shouldn't expect any benefit from the standard B6, B9 or B12 supplements, we don't fully understand how all eight B vitamins interact in the body, and that people who are obese or eat a poor diet could well be deficient in at least one of them. So, he suggests, there may be an argument for taking B-vitamin supplements, but only if you take them all rather than a select few.

FLAVONOLS

There is some evidence that flavonols, found in dark chocolate, wine and tea, can mildly enhance blood flow to the brain, says Kennedy. So consuming them may boost brain functioning and alertness, although he points out that exercise is more effective than supplements at boosting brain blood flow.

WATER

Dehydration is often cited online as an explanation of why so many of us feel tired. There is some evidence to support the idea. One study at the University of Connecticut, for example, found that "mild dehydration" – a 1.5 per cent dip below the

body's normal water volume, which the team says can occur in the course of routine activities – can cause fatigue and difficulty concentrating, particularly in younger women. On the other hand, a 2 per cent drop in hydration is enough to make us feel thirsty, so if we drink normally we shouldn't get dehydrated very often and it probably isn't necessary to force down gallons of the stuff.

HORMONES

Also much trotted out in cyberspace is the notion that long-term stress drains the adrenal glands, leading to tiredness and weakness. Adrenal fatigue is not a diagnosis recognised by the medical establishment – it was James Wilson, a chiropractor and naturopath, who came up with it in 1998. "No scientific proof exists to support adrenal fatigue as a true medical condition," says Katherine Chubinskaya, an endocrinologist in Vancouver, Canada. Adrenal insufficiency, however, a condition in which the adrenal cortex does not produce enough hormones – is real enough but also rare, so is unlikely to be the cause of most common fatigue.

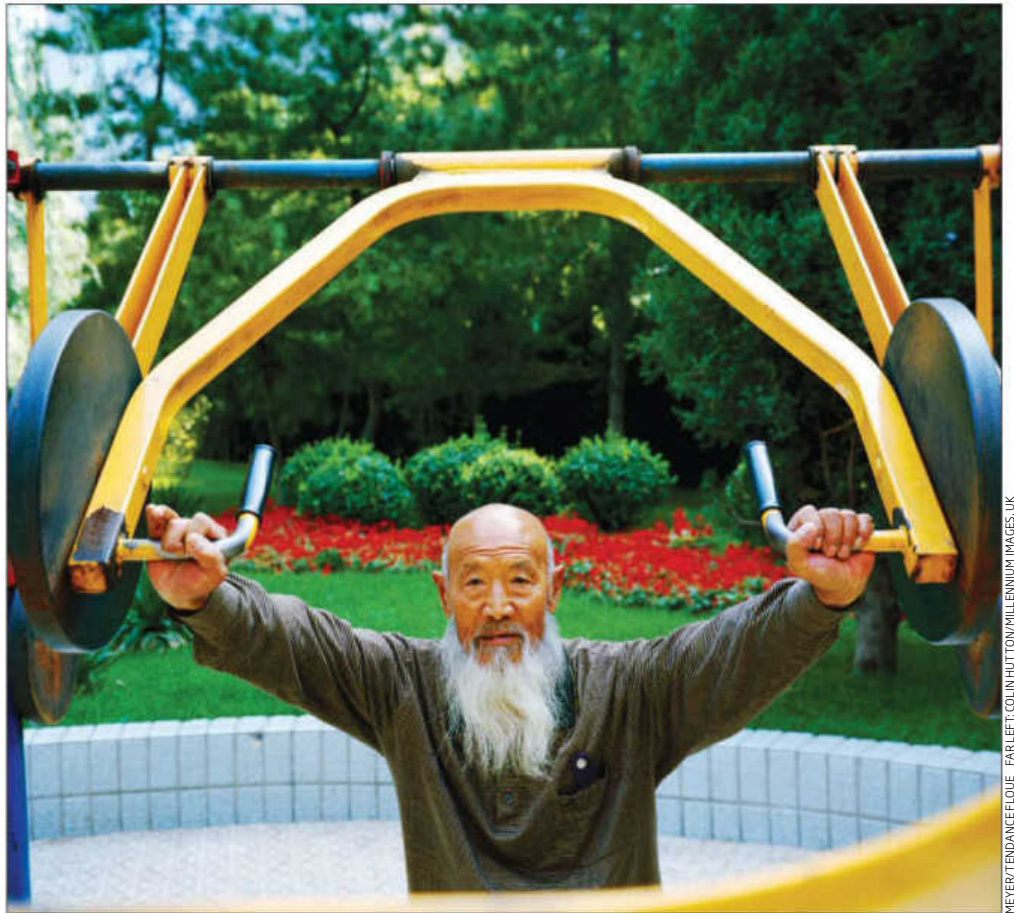
exertion – to reduced fatigue. “People with fatigue hate to hear this, but exercise can make a big difference,” she says. This may explain why people who start exercising regularly often report sleeping better, when some studies show they don’t actually sleep for any longer. Quality of sleep may be more important than quantity.

Fight fat, fight fatigue

As well as resetting the SCN, exercise fights the flab, and there are good reasons to think that reducing fat levels could help tackle fatigue. Body fat not only takes more energy to carry around, but releases leptin, a hormone that signals to the brain that the body has adequate energy stores. Studies have linked higher leptin levels to greater perceived fatigue, a finding that makes perfect sense from an evolutionary perspective: if you aren’t short of food, you don’t need the motivation to go out and find some. Interestingly, people who fast regularly often report feeling more energetic than when they ate frequently.

With obesity on the rise, leptin signalling might well be a common reason for feeling tired all the time. But there could be something else at play. People who carry excess fat also show higher levels of inflammation, a part of the body’s immune response that rouses other parts into action by releasing proteins called cytokines into the bloodstream. Body fat stores large quantities of cytokines, which may mean that more end up circulating, too. As well as stimulating the immune system, pro-inflammatory cytokines also make you feel drained of energy, as anyone who has ever had a common cold can attest. In 1998, Benjamin Hart at the University of California, Davis, argued that this feeling is an evolved strategy to help fight a bacterial or viral attack: when you need time to rest and recuperate, fatigue is your friend.

Animal studies have shown this effect in action. In one, Harrington gave mice a drug that causes low-level inflammation. She found that while they still moved around their cages and ate as normal, they avoided the running wheels. Contrast that with



MEYER/TENDANCE/LOUE FAR LEFT: COLIN HUTTON/MILLENNIUM IMAGES, UK

5.6

hours per week:
Productive
work time lost
through fatigue

Source: *Journal of
Occupational &
Environmental
Medicine*, vol 49, p 1

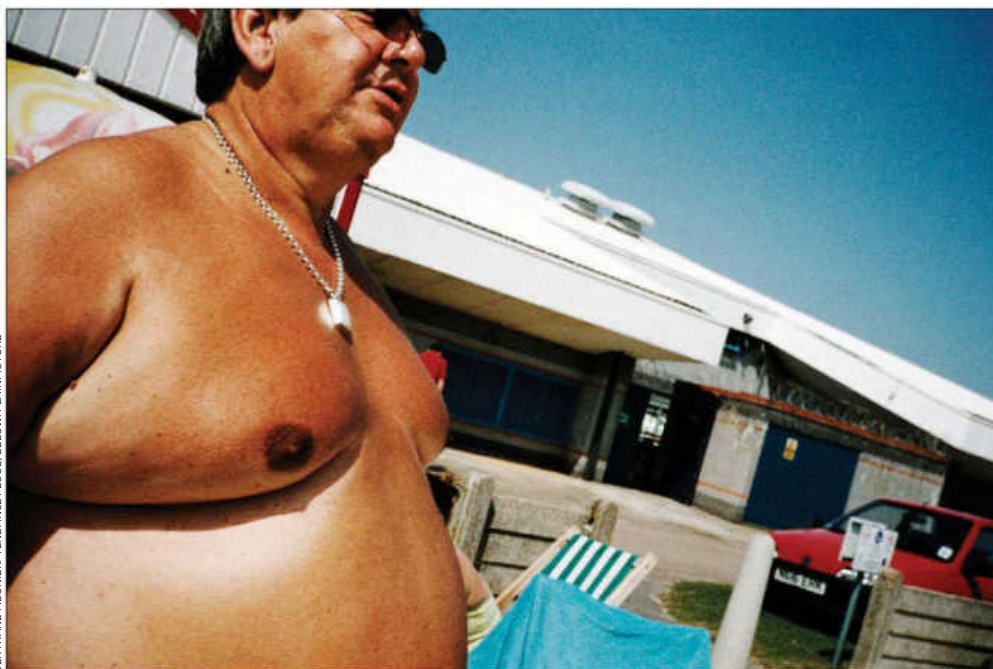
healthy mice, which seem to seek out the wheels for kicks. “It is like wanting to go out and be active, and have fun and do something that is not necessary for just staying alive.” If low-grade inflammation robs mice of their zest for life, there’s no reason, she thinks, to suspect something similar shouldn’t hold for people.

Robert Dantzer at the University of Texas M. D. Anderson Cancer Center, Houston, and colleagues have found changes in a few key brain areas that might account for a lack of motivation. They describe how inflammation alters activity in motivation-linked brain areas such as the fronto-striatal networks involved in reward-based decision-making, and the insula, which processes the bodily sensation of fatigue. These changes could explain aspects of fatigue such as a lack of motivation, uncertainty about what to do, and simply being aware of feeling sapped.

Exercise resets the circadian clock and banishes body fat – both fight fatigue

Even if you’re not overweight or sick, inflammation could still be running you down. A sedentary lifestyle, regular stress and poor diet – one high in sugar and low in fruits and vegetables – have all been linked to chronic, lower-level inflammation. There is also preliminary evidence that disruption of circadian rhythms can increase inflammation in the brain. So could lifestyle-related inflammation help to explain why so many of us feel so tired so much of the time? “The answer is yes,” says Dantzer. Epidemiological surveys do point to a relationship between fatigue and elevated levels of IL-6, an inflammatory marker, he says.

It’s early days, but inflammation is emerging as potentially a common pathway linking fatigue to everything from poor-quality sleep and



Living it large and physical inactivity can lead to feelings of exhaustion

physical inactivity to a bad diet. If that's correct, then a handful of potential lifestyle changes could go a long way to fighting everyday fatigue: more exercise, and eating more fruits and vegetables that contain high levels of polyphenols (such as resveratrol in grapes or curcumin in turmeric), which some studies suggest can reduce inflammation.

Inflammation probably isn't the whole answer, though, says Anna Kuppuswamy, a neuroscientist at the Institute of Neurology at University College London. Kuppuswamy studies people who suffer debilitating fatigue in the aftermath of a stroke, a time when their brains are highly inflamed. "Inflammation is definitely a trigger for fatigue. But what is frustrating is that we find fatigue in people long after inflammatory markers normalise," she says.

Another factor muddying the waters is that biological signals that might lead to a feeling of overwhelming exhaustion in one person won't necessarily trigger it in another. Some people are able to push through it, says Kuppuswamy.

That requires motivation, low levels

12

per cent of working parents are exhausted by their children but...

5

per cent of parents are fatigued by work

Source: Pew Research Center

of which are clearly an important aspect of fatigue. So some researchers have been looking at the role of dopamine – a neurotransmitter that drives us to seek out pleasure. When dopamine is lost, as happens in Parkinson's disease, for example, the depression and apathy that accompanies it can be crushing.

Low dopamine is also implicated in depression, as is reduced availability of another neurotransmitter, serotonin. Since the vast majority of people with major depression report severe



fatigue, and about one in five people become depressed at some point in their lives, it's no wonder that depression is also a potential common factor in fatigue.

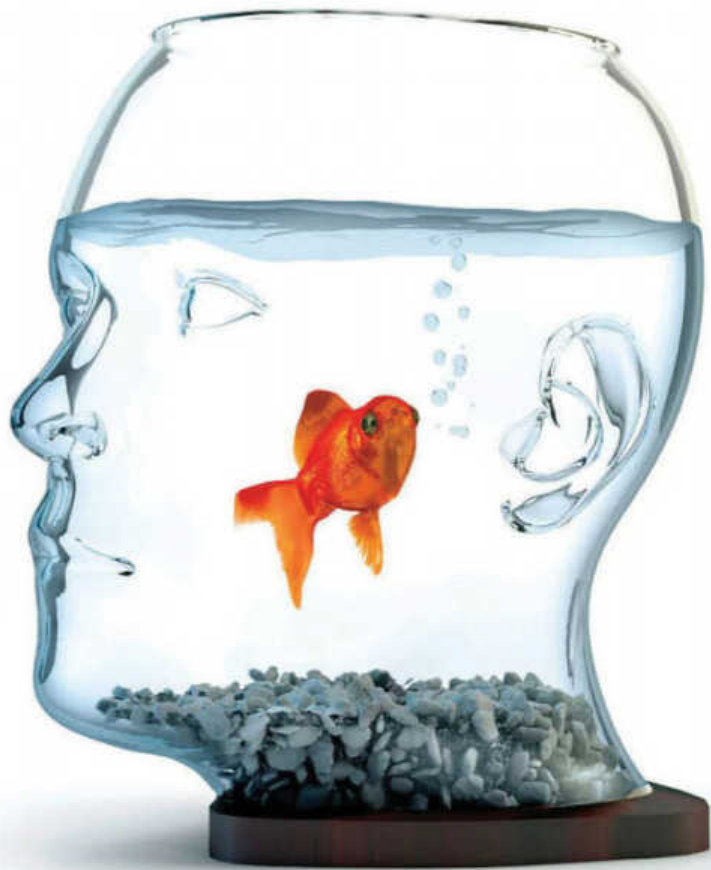
Body and mind

Ranjana Mehta, director of the NeuroErgonomics Lab at the Texas A&M Institute for Neuroscience, is one researcher who points to widespread depression as an explanation for why so many of us feel so drained. As her team has recently shown, the kind of mental exhaustion that accompanies depression can lead to a real sense of physical fatigue. In experiments, people who were asked to lift weights while doing mental arithmetic had 25 per cent less endurance than those who simply lifted weights. Subsequent imaging studies showed why: thinking hard lowers activity in frontal brain regions, which are involved in directing movements as well as having a hand in concentration. When the brain is challenged, it can make muscles tired, too.

With so many emerging causes for fatigue, interest in trying to crack the problem is growing. The US National Institutes of Health is in the planning stages of a programme aimed at finding the elusive physical signatures of fatigue. Harrington says that better animal models are needed, along with a concerted effort from many more researchers to rescue fatigue once and for all from medical obscurity. "I've done a lot of work on this because I think we can crack it," she says. "But I do feel pretty alone out there."

In the meantime, Harrington's advice is not to let fatigue stop you doing something you enjoy. In fact, it is worth forcing yourself to keep at it because a potent reward could trigger the release of dopamine in brain areas linked to motivation and alertness. Alternatively, do something stressful: the release of adrenaline could help you overcome lethargy. Ideally, put stress and enjoyment together. As Harrington says, "who feels fatigued when they're on a roller coaster?" ■

Emma Young is a science writer based in Sheffield, UK



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FORGING AHEAD

We have blended metals the same way for millennia. Boy, did we miss a trick, finds **James Mitchell Crow**

ONE OF the oldest shipwrecks ever discovered lies off the southern coast of Turkey. First glimpsed by a young sponge diver in 1982, it was carrying a curious cargo: 9 tonnes of copper and 1 tonne of tin. A curious cargo, that is, unless you know the recipe for bronze. The Uluburun wreck, named after a nearby town, dates from 1300 BC, smack in the middle of the Bronze Age.

Today, arguably, we live in the steel age, but the principle underlying our defining material remains the same. You take a pure metal and enhance it by adding a pinch of another element. One part tin to nine parts copper gives bronze; a smattering of carbon added to iron yields steel. This is the recipe for making alloys – materials whose strength, durability and workability make them the basis of everything in the modern world from cutlery to lampposts to bridges.



BORUT FURLAN/GETTY



The Uluburun wreck carried a precious cargo of bronze

modern technology (see diagram, page 36).

The heretical idea to throw out the established recipe came to researcher Jien-Wei Yeh in 1995. Driving across the Taiwan countryside to a meeting in Taipei, Yeh found himself pondering a problem ancient alloy-makers were already familiar with: there's invariably a point beyond which adding more of the alloying elements negates their benefits. At the atomic scale, the additive atoms start to form little clusters of metal-within-metal that make the material brittle.

Yeh's sudden thought was that the concept of entropy might provide a workaround. Entropy is a way of quantifying disorder in a system, and the rules of thermodynamics say that when something is more disordered it is more stable. So rather than make orderly alloys from one main element spiked with pinches of others, why not mix five, six or more elements? Swirl together enough elements in equal proportions, Yeh reasoned, and the resulting cocktail would be so disordered that there would be no chance for those crumble-inducing clusters to form.

Yeh was convinced he was on to something – so much so that he didn't go home after his meeting. Instead, he drove 80 kilometres back to his lab at National Tsing Hua University in Hsinchu City and immediately assigned a research student to work on the idea. "He produced the first high-entropy alloy within one or two weeks," Yeh says. Within a year, they had made at least 40 different ones. From the very start, their properties looked promising: they were hard, tough and corrosion resistant.

But there was a problem. Yeh and colleagues couldn't be sure what they had made. Electron microscopy and firing beams of X-rays at a new alloy can usually tell us its structure, but

Yeh's high-entropy creations were so unlike any other material that he had no reference data to make sense of what he was seeing. He spent the next eight years systematically making new materials, changing the composition bit by bit and comparing X-ray and microscopy scans until he had learned how to interpret them. In 2004, he was finally ready to unveil his idea.

Treasure maps

It came at an opportune moment. "In the past 10 years, we've run out of ideas for new alloy bases for high-temperature structural metals," says Dan Miracle, who works on jet turbines at the US Air Force Research Laboratory in Ohio. Once the initial scepticism had subsided, other researchers began to try their hand at making the new high-entropy alloys.

It was a daunting new research space. Imagine mixing equal amounts of five or more of the 60 or so elements commonly used in commercial materials in equal proportion. That gives you about 10^{40} possible combinations, says Dierk Raabe at the Max Planck Institute for Iron Research in Dusseldorf. Relax the rules to allow 5 per cent variation in the proportions of the elements and you jump to 10^{120} combinations. "That's a vast untapped reservoir of possible compositions and properties we have not discovered yet," says Raabe.

The trouble is we could never even in principle make and test all these possible alloys, and it is not obvious where to begin looking for the ones with desirable properties. "I think we're going to need treasure maps, theory-guided treasure maps, to show us where we can expect to find something

But are traditional alloys the best we can do? Increasingly, metallurgists are questioning this received wisdom. By ripping up the millennia-old rulebook, they are making wild metallic mixtures where no single element dominates, and with it producing materials the likes of which we have never seen. With applications from nuclear fusion reactors to jet engines to basic chemistry and more, it's a rich new material seam to mine – and we've only just begun to scratch the surface.

There are good reasons why we have made alloys in the same way for so long. Because their layers of identical atoms can slip past each other easily, pure metals are soft. That's why gold panners can tell a pure nugget just by biting it. But introduce interloper atoms and you can disrupt that slipping, producing a tougher material. This idea has furnished us with many of the materials that underpin

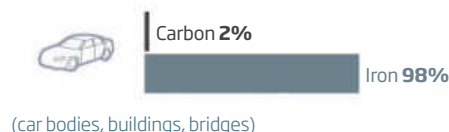
Unalloyed success

Almost all the alloys in common use follow the same recipe: lots of one metal and a mere sprinkling of others

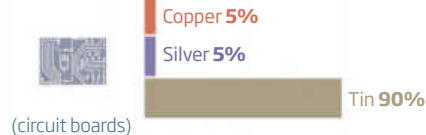
Bronze piping



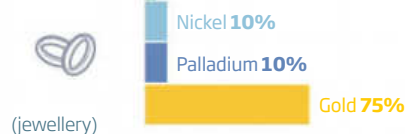
Steel



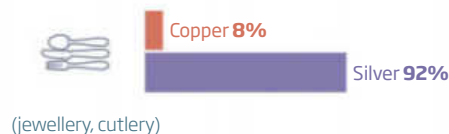
Solder



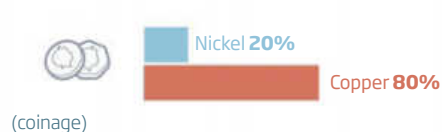
White gold



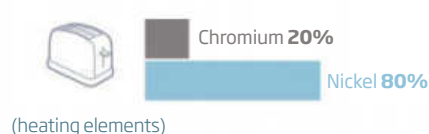
Sterling silver



Cupronickel



Nichrome



really interesting,” Raabe says.

The internal structures of high-entropy alloys are so different, however, that we can’t use existing theories to predict their behaviour. But even without a map, researchers have already made a few expeditions into uncharted territory – and come back with some exotic new materials. “We’ve seen some properties that are a little bit expected, and others that are totally unexpected,” says metallurgist Cem Tasan at the Massachusetts Institute of Technology.

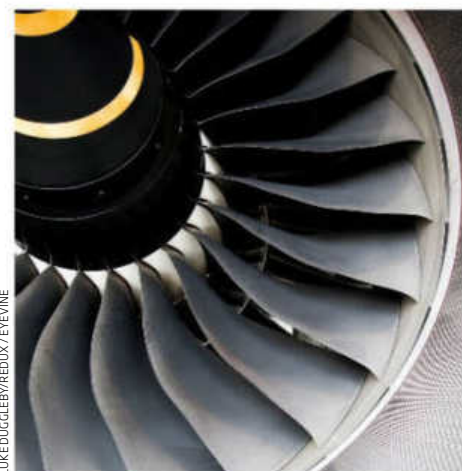
One of those unexpected findings has to do with brittleness. All known alloys become more shatter-prone when cooled, but in 2014 Easo George at Ruhr University in Bochum, Germany, and his team found a high-entropy alloy of iron, manganese, nickel, cobalt and chromium that became less brittle the colder it got, right down to -200 °C.

Why the material bucks the trend is not yet clear, but it has already caught the eye of researchers hoping to make nuclear fusion a reality, says George. Taming fusion, the process that powers the sun, involves containing a cloud of charged particles at temperatures in excess of 100 million degrees. This in turn requires superconducting electromagnets that must be kept very cold – without breaking. “You need high strength at cryogenic temperatures, and if it fails you need graceful rather than catastrophic failure,” says George. His alloy isn’t magnetic, but it is made from elements with interesting magnetic properties, so similar alloys might combine magnetism with strength at low temperatures.

Hard to crack

This is not the only cast-iron principle of materials science that looks a little more pliable with the advent of high-entropy alloys. There’s also the idea that the harder something is, the more prone it is to crack when struck: think of a soft clay compared with a hard china teacup. Earlier this year, Raabe, Tasan and their colleagues stumbled upon a high-entropy alloy containing iron, manganese, cobalt and chromium that ignores this rule (*Nature*, vol 534, p 227). They think this behaviour must stem from multiple crack-preventing mechanisms at play, corresponding to various atomic rearrangements the material can adopt to absorb the force of an impact.

The chemical properties of some of these alloys are confounding researchers, too (see “Chaotic catalysts”, right), making it all the



LUKEDUGGLEBY/REDUX / EYEVINE

more important to work out how to make the useful ones. One brute-force approach, adopted by Matthew Kramer and his team at the US Department of Energy’s Ames Lab in Iowa, is simply to try out as many combinations as possible. They have developed a machine that can 3D print up to 30 rod-shaped alloy samples in an hour and test their physical properties automatically.

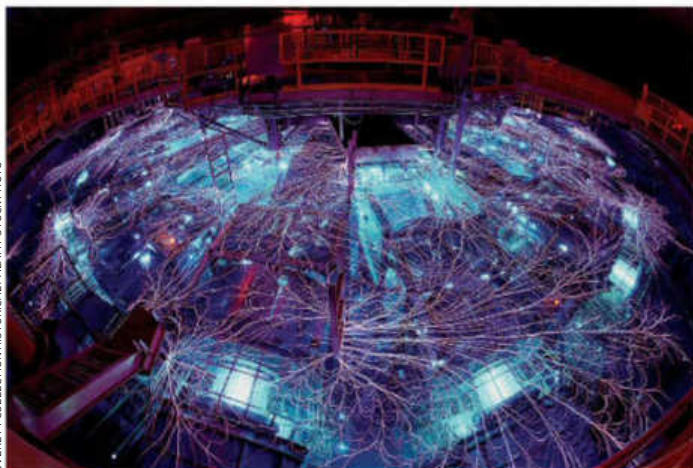
But what are we looking for? With more ingredients needed to make these new materials, some of them exotic and expensive, it’s hard to see a high-entropy alloy replacing cheap, plentiful steel in buildings or bridges, for instance. But besides nuclear fusion reactors, there are plenty of niche environments where we would wish for better materials than we currently have.

High on the wish list are alloys that would turn waste heat – from a car exhaust, say, or laptop chip – into electrical energy. Materials that can perform this trick, known as thermoelectrics, spontaneously generate a current when one side of the material is

“We’ve seen some properties that are expected, and some totally unexpected”

hot and the other cold. That requires good electrical conductivity, but poor thermal conductivity to maintain the temperature difference. In regular materials electrical conductivity goes hand in hand with thermal conductivity, but early research hints high-entropy alloys might get around this logjam: their structural complexity could suppress heat flow through the material, while allowing electrons to whizz through unimpeded.

Miracle’s employer, the US Air Force, also



From jet engines to fusion reactors, better alloys mean smarter technology



has some special material requirements. He is hunting for an alloy that can raise the operating temperature of a jet engine: the hotter you run a turbine, the more efficiently it performs. "Getting better gas mileage out of our jet engines is way more important than lightening the load a little bit by making a lighter wing material," he says.

A random search for this sort of material is unlikely to pay dividends – but we can narrow

the field using what we already know. Miracle is concentrating on a cluster of elements in the centre of the periodic table known as the refractory metals. These elements, including molybdenum and niobium, have unusually high melting points around 2500 °C, compared with 1455 °C for nickel, on which jet engine alloys are now based.

Pure niobium and molybdenum corrode too quickly to be useful, says Miracle. Mix

them with other materials that offer corrosion resistance, however, and new possibilities might emerge. So far he has shown that high-entropy refractory metal alloys do indeed remain strong at temperatures beyond the wilting point of existing nickel superalloys. Corrosion resistance is one of the next properties to test.

And it's not necessarily the case that the alloy-making revolution will bypass all but the highest of high tech. Not, at least, if Kevin Laws has his way. At his lab at the University of New South Wales in Sydney, he has made high entropy versions of those most ancient of alloys – bronze and brass. Both are so useful that they are still all around us, from keys and coins to bathroom taps. The main metal in conventional brasses and bronzes is copper, a costly metal. Laws substitutes most of this with nickel, manganese, zinc and aluminium, a mixture that's less expensive overall and gives better performance. "We've made them stronger, more corrosion resistant and cheaper," says Laws. It looks set to be one of the first commercially produced high-entropy metals. Laws's team has already signed an agreement with Swiss alloy-makers Ampco Metal, who will probably use it first for making super wear-resistant brass parts for industrial machines and potentially car engines.

Back when the Uluburun ship was sailing, alloys were used to make art, utensils and tools, as well as a new weapon that would help shape the jostling empires of the time: the sword. Who knows what technologies the new era of mixed-up metals will bring? Perhaps they will be just as world-changing. ■

CHAOTIC CATALYSTS

Gold is not normally the sort of material you mess around with, it being rather valuable and all. But using the knowledge gleaned from mixing up metals for high-entropy alloys (see main story), Kevin Laws from the University of New South Wales is taking gold and other highly expensive metals and melding them into unholy mixtures for chemical use.

The plan is to create new catalysts, materials that speed up chemical reactions that would otherwise be inconveniently slow. Catalysts are an indispensable enabler in labs that make medicines, fuels, plastics and in technologies such as the catalytic converters in our cars.

Catalysts are often made of metals, especially precious metals such as gold, platinum and palladium. The hope is that by mixing a precious metal with a host of other elements, you can conjure up a decent catalyst more cheaply. "If you can make a high-entropy alloy with good catalytic properties, which uses only 20 per cent as much palladium, you've saved a

tonne of money," says Dan Miracle, an alloy researcher at the US Air Force Research Laboratory in Ohio.

How might mixed-up alloys achieve this? The magic of catalysts mainly happens in tiny surface defects where pools of electric charge form and enable molecules to dock and be transformed. Laws thinks that the random internal structure of high-entropy alloys would supply more of these active defects. And he says his initial research shows that high-entropy precious metal alloys do have a similar catalytic performance to pure platinum or palladium, while also boasting the robust mechanical properties of other multi-metal alloys.

That might take us beyond just catalytic converters. For decades, chemists have been on a quest to make a catalyst that can mimic photosynthesis, splitting water into hydrogen fuel. So far performance has been lacklustre, but high-entropy alloys could be the answer, Laws thinks. "There's great potential there for having something that can split water more effectively," he says.

James Mitchell Crow is a science journalist based in Melbourne, Australia

History lessons

A clever database will help us understand our past and build a better future, finds **Laura Spinney**

MY NAME is Ozymandias, king of kings: look on my works, ye mighty, and despair!" So run the famous lines of Percy Shelley's poem about Ramses the Great, a pharaoh who ruled Egypt's New Kingdom in the 13th century BC, when it was the world's most sophisticated society. But the poem's theme is the transience of glory. It describes the ruins of a giant statue to Ramses that lie scattered in the desert: "Round the decay of that colossal wreck, boundless and bare, the lone and level sands stretch far away."

Why was the New Kingdom so advanced, and what triggered its downfall? There is no shortage of theories, and each has its champions. This is the way history tends to work: theories are put forward, their strengths and weaknesses are discussed, and then they line up alongside all the alternative ideas. Like old sailors, they never really die. A new project called Seshat, after the ancient Egyptian goddess of knowledge, aims to change that.

Seshat is a vast and growing database of historical and archaeological knowledge that can be explored using scientific techniques. That makes it a powerful tool for testing and ultimately discarding hypotheses. "A cemetery for theories," is how Seshat co-founder Peter Turchin at the University of Connecticut in Storrs describes it. By making history more evidence-based, he and his colleagues hope it will become more relevant. They believe that understanding the forces that have shaped human societies in the past will give us more power to predict the future – and perhaps even to direct it by advising politicians and

lawmakers on how to avoid the pitfalls of the past.

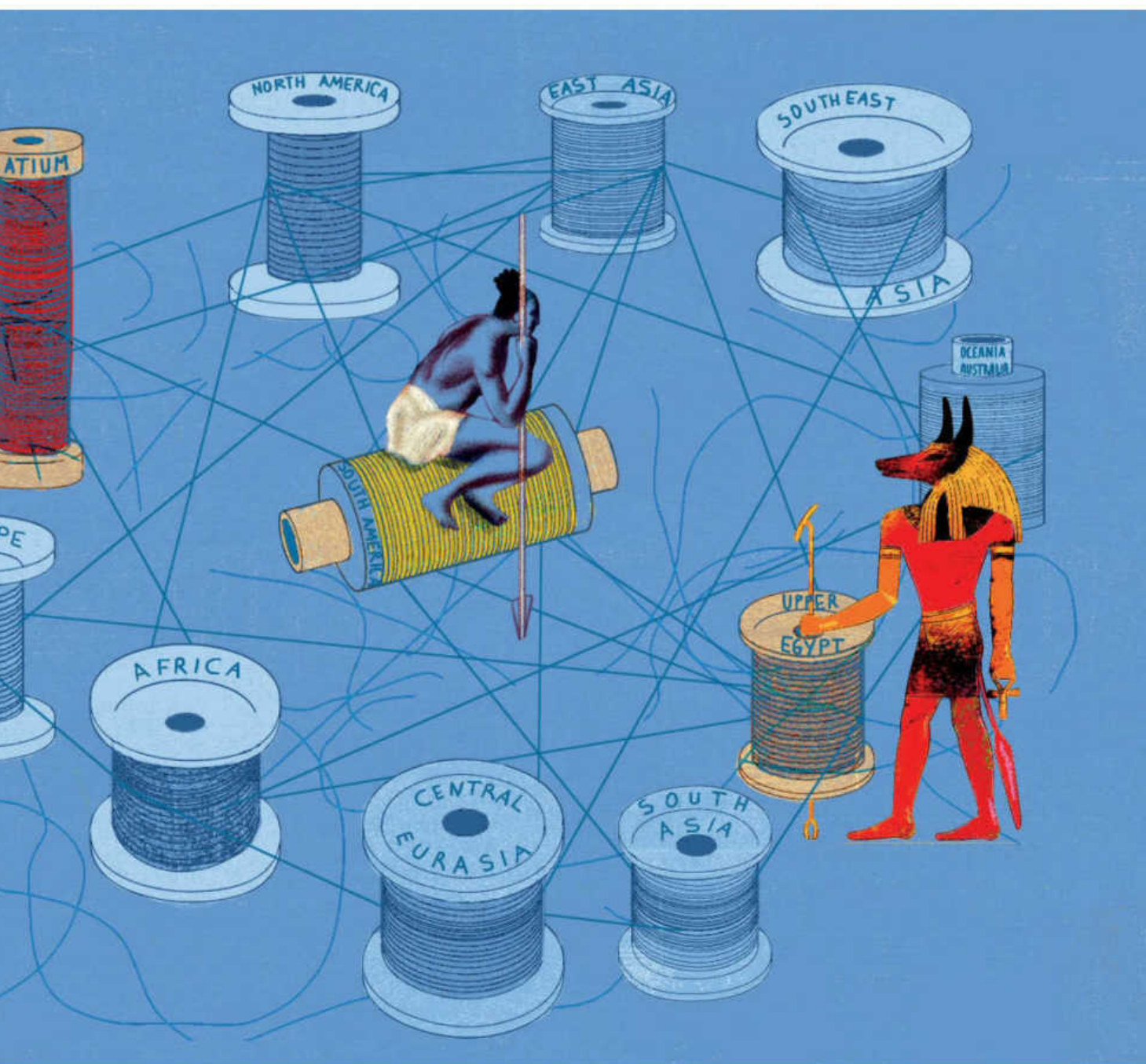
Historians may reasonably point out that their discipline has always been evidence-based. Certainly we are awash with information on past societies, but the Seshat team argues that this store of knowledge is now so huge and widely dispersed that no single human brain, or even team of brains, can hope to make sense of it all. What's more, although some historical patterns are visible to the naked eye, many are not. Teasing out complex and subtle interactions that operate over long timescales is a task that suits computers to perfection, so perhaps it's time more researchers invited them to collaborate? Gary Feinman, an anthropologist at the Field Museum in Chicago, certainly thinks so. He has watched how academia has responded to the deluge of data – with increasing specialisation and dwindling contact between knowledge "silos" – and sees Seshat as a precious counterweight to that. "We in historical and social scientific fields desperately need this kind of overarching, cooperative, comparative effort that crosses disciplinary boundaries," he says.

So, how does it work? Seshat, conceived in 2010, is certainly ambitious. It divides up the world into 10 regions and selects three sample areas within each, according to natural geographic features and the level of social development. To capture as much social diversity as possible, the researchers considered when the first complex society emerged – defining a complex society as a

chiefdom or state, with centralised control. They then chose one early, one intermediate and one late developer in each region.

These 30 areas make up Seshat's sample, for now – but eventually the aim is to span the entire world. For each area, data input covers hundreds of historical variables, including the existence of a military hierarchy, the use of a calendar and the population of the largest settlement. The unit of information is a "fact", which can take the form of a binary choice (presence/absence of writing, for example), a numerical value, or a range of values. Each fact is based on the consensus of specialist historians who meet periodically at





BEPPE JACOBBE

workshops, first to decide which variables to consider, and then to validate the facts collected. Facts can be accompanied by text that expresses uncertainty or controversy and, critically, provides sources. The data spans 10,000 years from the dawn of agriculture to the eve of the modern era in 1900.

So far more than 130,000 facts have been input manually by a band of plucky research assistants. Earlier this year, they completed the first phase, which covers the broad themes of warfare, agriculture, ritual and social complexity. Now they are working on phase two, which focuses on internal collapse and encompasses the themes of well-being,

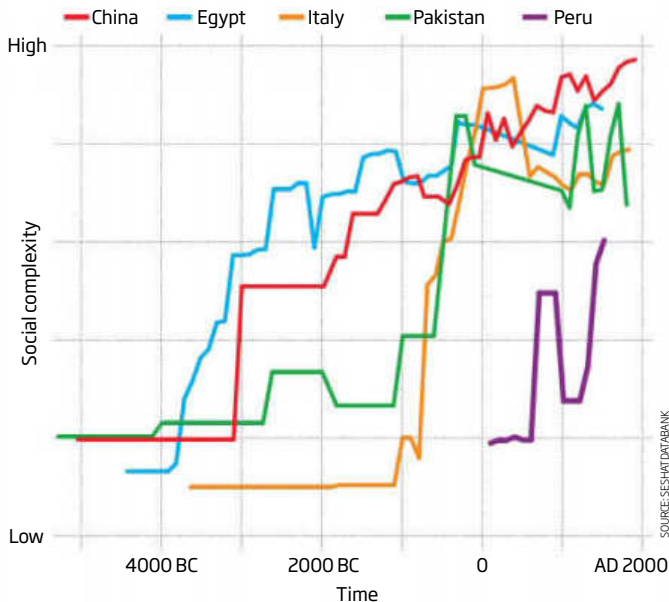
institutions, equity and religion. Once in the database, the facts are machine-readable and interlinked along spatial, temporal and thematic dimensions, allowing researchers to explore a rich terrain of links and patterns (see “Under Seshat’s hood”, page 40).

The first analysis using Seshat will be published soon. It’s an overview of the evolution of social complexity, identifying 53 variables involved, and using the database to compare the rise and fall of diverse societies across the globe since the Stone Age (see “The bumpy ride of progress”, page 40). It captures, for example, the precociousness of Egypt’s New Kingdom civilisation, with its

“The Romans didn’t just lose territory, they lost different types of texts and the economy became simplified”

The bumpy ride of progress

The first study from the Seshat historical database charts the rise and fall of societies across the world using 53 markers of social complexity



monumental architecture, taxation and peace treaties. It also charts the heights of social sophistication reached by the Roman Empire, and its dramatic fall in the first half-millennium AD. The Romans didn't just lose territory, "they lost different types of texts, the economy became simplified, and that complexity wasn't recovered until the Renaissance in the 16th century", says Turchin, who led the study. He sees it as "foundational" – more a description of general patterns than a

test of alternative ideas – but the "massacre of theories" will begin soon with the publication of a slew of papers setting competing hypotheses against one another. The Seshat team refers to these as "horse races" – the goal being to eliminate the weakest each time – and they will tackle some of the thorniest issues in current debates about the past.

For example, Tom Currie at the University of Exeter, UK, and others have been considering the origins of complex societies. They first

emerged around 10,000 years ago, when many humans were shifting from hunter-gatherer lifestyles to farming. Nobody thinks this is a coincidence. But, says Currie, there are two main explanations. One idea is that farming supports the proliferation of specialised non-productive roles such as leaders, bureaucrats and bookkeepers because it produces more food than foraging. The second holds that, with more food, a farming population grows, giving it an edge in fights against smaller, non-farming communities. These then club together, the better to overcome the enemy, and the farmers follow suit in an arms race towards ever-greater social complexity.

To test these competing ideas, the team used the Seshat database alongside crop models originally designed to estimate productivity under different future climate scenarios. "The developers of these models alter the parameters and run them forward," Currie explains. "We run them back." They do this using what's known about past climate and the timings of certain agricultural innovations. Once they have an estimate of productivity, they can calculate the proportion of a population that could fill non-farming roles without anyone going hungry, and find out how this fits with the recorded information on such things as numbers of bureaucrats and army size. The results should be published before the end of the year.

Using a similar approach, the researchers also hope to test theories that invoke climate as a major factor in the fall of societies. For example, did it trigger the collapse of the Mayan civilisation around the 9th century AD? This theory was made popular by Jared

UNDER SESHAT'S HOOD

Seshat is the ancient Egyptian goddess of knowledge. It's also the name of an ambitious database of historical information. Conceived in 2010, Seshat now contains more than 130,000 facts, all interlinked and machine-readable. This gives it some unique attributes. A computer can flag up contradictory entries. It can also exclude redundant variables using a statistical technique that picks out variables that correlate with one another.

Seshat's real novelty, according to IT expert Kevin Feeney at Trinity College Dublin, Ireland, is its ability to accommodate uncertainty of all types, "unknown unknowns as well as known unknowns". The historical record is

notoriously patchy but it's not always clear where the gaps in the information are. Seshat can highlight where details are missing or incomplete. It can even fill in some gaps using a statistical technique called multiple imputation, suggesting a range of possible answers based on what's known about related variables.

To make all this possible, Feeney's team built Seshat using the technology of the semantic web – a term coined by world wide web inventor Tim Berners-Lee to describe an extension of the regular web in which information is given well-defined meaning and linked in clever ways that only a computer can read. This makes the database flexible and able to learn by

generalising, just as humans do. Feeney calls it "a Wikipedia for computers". Researchers are now using Seshat to test competing historical theories and suggest ways we can learn from the past.

At the moment, a team is manually inputting the data, but in future, the process will start to become automated. Soon, for example, computers will search digital libraries such as JSTOR for the best sources for a given fact. Software will be added so that data can be crowdsourced from the public and the core database will also be linked to other, more specialised historical and archaeological databases. At that point, says Feeney, Seshat will start to grow very fast.

Diamond in his book *Collapse*. “The models are already suggesting that climate was not as big a factor in determining productivity as cultural innovations such as irrigation, manure, terracing, crop rotation and multicropping,” says Currie. The Maya were great innovators when it came to farming, so perhaps they were better able to withstand climatic change than Diamond and others have given them credit for – although, for the moment, this idea remains untested.

How to build an empire

Seshat should also be able to tell us whether agriculture alone was enough to drive the growth of empires, as some historians believe, or whether other factors were necessary too. Turchin’s own theory, for example, sees advances in military technology as an important driving force ratcheting up social complexity on either side of lines of conflict. Meanwhile, anthropologist and Seshat co-founder Harvey Whitehouse at the University of Oxford is using the database to test his ideas about rituals. These include a theory that the introduction of farming drove people to adopt new kinds of religious practices such as prayer, which in turn brought them together in larger coalitions of greater social complexity.

The team is excited to be able to put such ideas to the test, but also braced for disappointment. “If one of my theories falls by the wayside, so be it,” says Turchin. They are also hoping that their analyses will expose unsuspected interactions, perhaps in turn suggesting new theories. One person who thinks this is a real possibility is Ian Morris, a historian at Stanford University who has long argued that geography and human ingenuity interact in complex and surprising ways. To give an example, Britain’s mastery of shipbuilding and navigation put the Americas within reach and so helped overcome the geographical misfortune of being located at the extreme edge of Europe.

Seshat could help fill out the picture in other ways too. “Historians have long been aware that the sources available to them emphasise the importance of material elements over cultural ones,” says Morris. That’s because it is easier to describe or code an innovation, such as developments in pottery, than a cultural one. Yet something like a shift in religious thought or agricultural practice could be even more influential.

Morris thinks Seshat will also help historians move beyond an emphasis on extraordinary individuals. The searchable

database allows them to set, say, Abraham Lincoln in the context of his times and his contemporaries, and to explore to what extent his qualities accounted for events such as the emancipation of slaves and the preservation of the Union during the US civil war.

When the project began, there was a lot of suspicion and hostility from historians. But increasing numbers have become involved and now it’s hard to find any that object to it in principle. That’s not to say it doesn’t have its critics and limitations. Feinman, for example, points out that the current sample size of 30 societies is relatively small. So even if

“Seshat could establish what conditions lead to stable and peaceful societies”

Seshat delivers a punch to a theory, he says, “I’m not sure it will be the knock-out blow”.

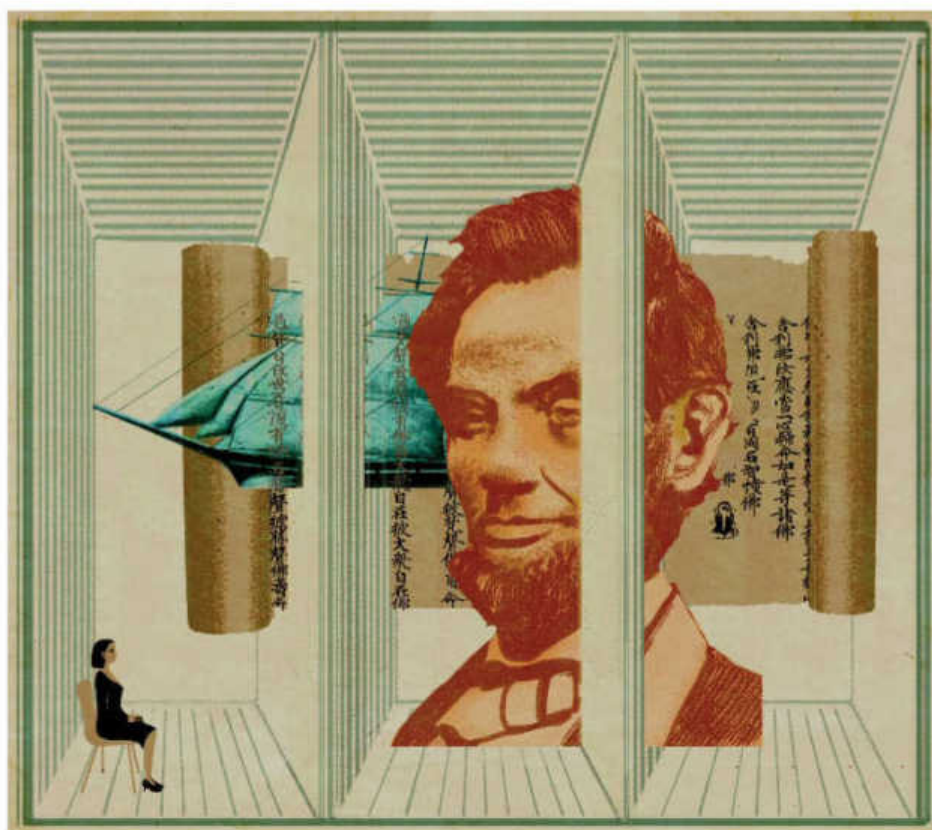
Others question Seshat’s objectivity. Jennifer Edmond at Trinity College Dublin in Ireland, who coordinates a digital historical research resource called CENDARI, says coded data is open to interpretation. “Every time you use something like Seshat or CENDARI, there is the fingerprint of the scholars who put it together,” she says. “We can’t avoid that. The question is, how can we make it as minimal or as transparent as possible?” Computer scientist Kalev Leetaru of Georgetown University in Washington DC,

who runs a digital inventory of the world’s media called GDELT, says that such initiatives will only become really powerful when machine coders replace biased humans.

Despite such qualms, the Seshat researchers believe their approach has real value. Already, relevant findings are being channelled to policy-makers, in line with the stated aims of the Evolution Institute, a think tank in San Antonio, Florida, which supports the project. For instance, Turchin has been in dialogue with the Foreign Policy Research Institute in Philadelphia about demographic cycles and social breakdown. And Whitehouse has been talking to UK politicians with an interest in terrorism about factors that affect the structure, spread and survival of armed groups. In future, he says, Seshat could establish what conditions lead to more cohesive, stable and peaceful societies, as opposed to trying to impose “democracy” everywhere. And Turchin thinks it holds historical lessons that could inform decisions about where the European Union goes, post-Brexit.

Next February, when analysis of phase two data begins, Seshat researchers will focus their efforts on what causes societies to collapse. If one lesson is already clear from their analysis of the rise and fall of social complexity, it is that, in the long run, social evolution can’t happen without collapse. That is a message politicians may find hard to swallow. ■

Laura Spinney is a writer based in Paris, France



Tracking the ocean's avengers

Why would a humpback whale save a seal from certain death at the jaws of a killer whale? When Robert Pitman saw this for himself, he had to find out

You first saw humpback whales behaving strangely in 2009. What happened?

We were doing killer whale research in Antarctica and had the BBC on board filming *Frozen Planet*. We saw some killer whales interacting with some humpbacks and thought it could be an attack. We went over to have a look and the humpbacks were a little agitated, but it wasn't a full-on attack and the killer whales ended up going away. We weren't quite sure what was going on, but when we looked at the BBC footage, we saw there was a Weddell seal between the two humpbacks. So we thought maybe the seal was trying to escape and found refuge.

We followed the killer whales and soon they started attacking a crabeater seal on an ice floe, creating waves to try to wash it off. A few minutes later, the two humpbacks we had left behind came charging in and chased after the killer whales, slapping their flippers and

making a nuisance of themselves. This was different because the humpbacks were on the offensive. But we figured it was just mobbing behaviour, like when garden birds mob a predator to try to get rid of it.

When did you realise the whales were doing more than just driving a predator away?

Well, a couple of days later we saw some killer whales attacking a Weddell seal on an ice floe and there were a couple of humpbacks in the vicinity. We could tell they were agitated because we could hear them bellowing – it's an impressive sound. The killer whales washed the seal off the ice and it started swimming into open water. Then, suddenly, one of the humpbacks comes to meet the seal and, just as it gets to the seal, rolls over on its back and the water washes the seal onto its chest. The whale lifts its chest up out of the water with the seal on it.

PROFILE

Robert Pitman is a marine ecologist with the National Oceanic and Atmospheric Administration in La Jolla, California. His paper on humpback whale behaviour appears in *Marine Mammal Science* (DOI: 10.1111/mms.12343)

That sounds like pretty unusual behaviour for a whale...

Yeah – we were amazed to see it. But we immediately thought maybe the whale didn't know the seal was there, maybe this was all just coincidence. Then we looked at the BBC footage, and we saw that at one point the seal had started to slip off the whale's chest. The humpback used a 5-metre-long, 1-tonne flipper to gently nudge the seal back up onto its chest. Once we saw that, we knew it was no accident and something was going on.

What did you think was happening between the humpbacks and the seal?

It looked like altruism – as if the whales were acting out of concern for the smaller animal. But we are not talking about humans here, and when animals do something that appears to be altruism, I try to come up with rational explanations for it. But the reason wasn't obvious because, as best we know, animals always act in their own self-interest. "This needs an explanation," I thought.



This orca was all set for an easy meal – until the humpback appeared



is altruism. Humpbacks are coming in to drive off killer whales. That seems to be humpbacks acting against their own best interests.

Killer whales are fearsome animals. Why would humpbacks get involved?

Humpbacks spend their lives going to the feeding and breeding grounds their mother took them to, so they are more likely to be related to nearby individuals than to the population as a whole. As a result, it's in their interest to drive off killer whales that are attacking a nearby calf because they might be related. And humpbacks are so big and powerful, they have nothing to fear from killer whales – it's only the calves that are vulnerable. The killer whales respect them: if a humpback were to slap its tail on a killer whale, it could kill it outright.

It also turns out that humpbacks charge in when killer whales begin vocalising. There are reports of humpbacks coming in from 2 kilometres away. They don't know what the killer whales are attacking. It seems like the humpbacks have one simple instinct: when killer whales attack, you go in and try to stop them. So we think what's going on here is inadvertent altruism.

Is it altruism if it is inadvertent?

It is according to the definition I gave earlier. The key point is that the behaviour shows how altruism could evolve out of self-interest. Indeed, in animals it is really just another form of self-interest. I wouldn't be surprised if ultimately it is for humans too, because we admire altruism and it has its rewards: if you're a war hero, you get ticker-tape parades. Admittedly, human altruism is more complicated than that. With animals, I think it's relatively straightforward. Altruism has a place in their behaviour if it can be shown to be motivated by self-interest, and I think that is what's going on with humpbacks. You don't use terms like compassion and morality to explain this – it makes Darwinian sense.

Is there more to learn about whale behaviour?

Twentieth-century whaling reduced populations to the point where oceans were almost devoid of whales. But we've noticed a definite increase in numbers and I think their populations are beginning to recover to the point where we are seeing behaviours that we had no idea were out there. We need to be prepared for some more surprises in the way these animals interact with each other. ■

Interview by Joshua Howgego

What about other cetaceans – does their behaviour offer clues as to what was going on?

There are lots of anecdotes about dolphins helping other animals in distress, including humans. But that's different from the humpbacks: they were going in to help an animal being attacked by an apex predator.

So you set out to look for evidence of humpbacks disturbing killer whale hunts...

When we got back from the trip, I wrote to everyone I knew working on killer whales and humpbacks. I got several dozen responses from people saying they had seen something similar. I also checked the literature and found other examples. A lot of these were from naturalists or even tourists on whale-watching boats, but that makes sense as there are a lot more of them watching whales than biologists doing so. This showed me that there are records of this behaviour wherever there are humpbacks.

Are other researchers persuaded that humpbacks are helping other species?

It has taken a while to convince people. In the

animal world, altruism is a thorny issue because it can be difficult to explain in terms of natural selection. While certain acts can look like they are driven by compassion, researchers are wary of attributing such feelings to animals. It's amazing how it raises hackles. But people got to know I was doing this research

“Suddenly, the humpback rolls over and washes the seal safely onto its chest”

and they started looking at these interactions a little differently. Over the years, the number of sightings has built up to a critical mass. I think a lot of people who watch humpbacks now essentially agree with my interpretation of what is going on – although maybe not about why the humpbacks are doing it.

So are the whales being altruistic?

If you define altruism as a behaviour that increases the recipient's fitness at the cost of the performer's, then it's pretty clear that this

SCOTT HANSEN

Natural laws, or not

The world is wilder than our rules would predict, finds **Simon Ings**

How the Zebra Got its Stripes and Other Darwinian Just So Stories by Léo Grasset, Profile Books, £9.99; *The Serengeti Rules: The quest to discover how life works and why it matters* by Sean B. Carroll, Princeton University Press, \$24.95/£18.95; *Lysenko's Ghost: Epigenetics and Russia* by Loren Graham, Harvard University Press, \$24.95/£19.95; *The Great Derangement: Climate change and the unthinkable* by Amitav Ghosh, University of Chicago Press, \$22

JUST how much does the world follow laws? The human mind, it seems, may not be the ideal toolkit with which to craft an answer. To understand the world at all, we have to predict likely events and so we have a lot invested in spotting rules, even when they are not really there.

Such demands have also shaped more specialised parts of culture. The history of the sciences is one of constant struggle between the accumulation of observations and their abstraction into natural laws. The temptation (especially for physicists) is to assume these laws are real: a bedrock underpinning the messy, observable world. Life scientists, on the other hand, can afford no such assumption. Their field is constantly on the move, a plaything of time and historical contingency. If there is a lawfulness to living things, few plants and animals seem to be aware of it.

Consider, for example, the charming “just so” stories in French biologist and YouTuber Léo Grasset’s book of short essays, *How the Zebra Got its Stripes*. Now and again Grasset finds order and

coherence in the natural world. His cost-benefit analysis of how animal communities make decisions, contrasting “autocracy” and “democracy”, is a fine example of lawfulness in action.

But Grasset is also sharply aware of those points where the cause-and-effect logic of scientific description cannot show the whole picture. There are, for instance, four really good ways of explaining how the zebra got its stripes, and those stripes arose probably for all those reasons, along with a couple of dozen others whose mechanisms are lost to evolutionary history.

And Grasset has even more fun describing the occasions when, frankly, nature goes nuts. Take the female hyena, for example, which has to give birth through a “pseudo-penis”. As a result, 15 per cent of mothers die after their first labour and 60 per cent of cubs die at birth. If this were a “just so” story, it would be a decidedly off-colour one.

The tussle between observation and abstraction in biology has a fascinating, fraught and sometimes violent history. In Europe at the birth of the 20th century, biology was still a descriptive science. Life presented, German molecular biologist Gunther Stent observed, “a near infinitude of particulars which have to be sorted out case by case”. Purely descriptive approaches had exhausted their usefulness and new, experimental approaches were developed: genetics, cytology, protozoology, hydrobiology, endocrinology,

Is a single explanation enough to account for the zebra's stripes?

experimental embryology – even animal psychology. And with the elucidation of underlying biological process came the illusion of control.

In 1917, even as Vladimir Lenin was preparing to seize power in Russia, the botanist Nikolai Vavilov was lecturing to his class at the Saratov Agricultural Institute, outlining the task before them as “the planned and rational utilisation of the plant resources of the terrestrial globe”.

Predicting that the young science of genetics would give the

next generation the ability “to sculpt organic forms at will”, Vavilov asserted (quoting historian David Joravsky) that “biological synthesis is becoming as much a reality as chemical”.

The consequences of this kind of boosterism are laid bare in *Lysenko's Ghost* by the veteran historian of Soviet science Loren Graham. He reminds us what happened when the tentatively defined scientific “laws” of plant physiology were wielded as policy instruments by a desperate and resource-strapped government.

Within the Soviet Union, dogmatic views on agrobiolgy led to disastrous agricultural reforms, and no amount of modern, politically motivated

“If there is a lawfulness to living things, few plants and animals seem to be aware of it”



revisionism (the especial target of Graham's book) can make those efforts seem more rational, or their aftermath less catastrophic.

In modern times, thankfully, a naive belief in nature's lawfulness, reflected in lazy and increasingly outmoded expressions such as "the balance of nature", is giving way to a more nuanced, self-aware, even tragic view of the living world. *The Serengeti Rules*, Sean B. Carroll's otherwise triumphant account of how physiology and ecology turned out to share some of the same mathematics, does not shy away from the fact that the "rules" he talks about are really just arguments from analogy.

Some notable conservation triumphs have led from the discovery that "just as there are molecular rules that regulate the numbers of different kinds of molecules and cells in the body,

Ecological rules regulating a given place can help conservation efforts

there are ecological rules that regulate the numbers and kinds of animals and plants in a given place".

For example, in Gorongosa National Park, Mozambique, in 2000, there were fewer than 1000 elephants, hippos, wildebeest, waterbuck, zebras, eland, buffalo, hartebeest and sable antelopes combined. Today, with the reintroduction of key predators, there are almost 40,000 animals, including 535 elephants and 436 hippos. And several of the populations are increasing by more than 20 per cent a year.

But Carroll is understandably flummoxed when it comes to explaining how those rules might apply to us. "How can we possibly hope that 7 billion people, in more than 190 countries, rich and poor,



AGE FOTOSTOCK/ALAMY STOCK PHOTO

with so many different political and religious beliefs, might begin to act in ways for the long-term good of everyone?" he asks. How indeed: humans' capacity for cultural transmission renders every Serengeti rule moot, along with the Serengeti itself – and a "law of nature" that does not include its dominant species is not really a law at all.

Of course, it is not just the sciences that have laws: the humanities and the arts do too. In *The Great Derangement*, a book that began as four lectures presented at the University of Chicago last year, the novelist Amitav Ghosh considers the laws of his own practice. The vast majority of novels, he explains, are realistic. In other words, the novel arose to reflect the kind of regularised life that gave you time to read novels – a regularity achieved through the availability of reliable, cheap energy: first, coal and steam, and later, oil.

No wonder, then, that "in the literary imagination climate change was somehow akin to extraterrestrials or interplanetary travel". Ghosh is keenly aware of and impressively well informed about climate change: in 1978, he was nearly killed in an unprecedentedly ferocious tornado that ripped through northern Delhi, leaving 30 dead and 700 injured. Yet he has never been able to work this story into his "realist" fiction.

His hands are tied: he is trapped in "the grid of literary forms and conventions that came to shape the narrative imagination in precisely that period when the accumulation of carbon in the atmosphere was rewriting the destiny of the Earth".

The exciting and frightening thing about Ghosh's argument is how he traces the novel's narrow compass back to popular and influential scientific ideas – ideas that championed uniform and

"In the literary imagination climate change was somehow akin to aliens or interplanetary travel"

gradual processes over cataclysms and catastrophes.

One big complaint about science – that it kills wonder – is the same criticism Ghosh levels at the novel: that it bequeaths us "a world of few surprises, fewer adventures, and no miracles at all". Lawfulness in biology is rather like realism in fiction: it is a convention so useful that we forget that it is a convention.

But, if anthropogenic climate change and the gathering sixth mass extinction event have taught us anything, it is that the world is wilder than the laws we are used to would predict. Indeed, if the world really were in a novel – or even in a book of popular science – no one would believe it. ■



VITO ELEFANTE/GETTY

Oh, what a lovely war

Why fight cancer when you can sing about it, says **Mary Halton**

A Pacifist's Guide to the War on Cancer
National Theatre, London, 14 October
to 29 November

FIGHTS. Losses. Survivors. The language of cancer is a battleground littered with violent metaphors, but a new production at London's National Theatre plans to change that, with an "all singing, all dancing examination of life with a cancer diagnosis". Oh yes, a musical. About cancer.

In its very title, Bryony Kimmings and Brian Lobel's *A Pacifist's Guide to the War on Cancer* issues an open challenge to public discourse on serious illness. "[Musicals can] seem like puff pieces of art," says Kimmings, "but actually if you think about the good ones, they deal with huge issues. Cancer should definitely be a musical."

Lobel, who was himself treated for cancer at a young age, describes his role in the production as "navigating the muck of cancer... there's just so much conflicting information and loud political noise".

But even violent metaphor can be a useful tool, as Elena Semino at Lancaster University, UK, explains. She analysed the language people with cancer use in online forums, and discovered that the idea of being a fighter is sometimes empowering – with one key caveat. "The crucial thing is that nobody should have that particular way of being imposed on them. If the main way you have to conceive of your illness is as a battle that you need to fight and win, then if you're losing it's kind of your fault... it can have all sorts of negative consequences."



MARK DOUET

With a view to subverting this kind of narrative, Kimmings and Lobel developed the show with an "ICU" of 10 people who'd had cancer or were currently in treatment. Sure enough, the inclusion of a quote from Audre Lorde, an African-American

"To be asked to hate some of me, to fight some of me, is brutal. It doesn't matter how kindly meant it is"

writer and activist who had felt empowered by the language of fighting cancer, divided opinion within the group.

While Semino's study showed that people are likely to use violence and journey metaphors to describe their experience

of cancer, it also revealed, perhaps unsurprisingly, that experiences of serious illness can be deeply individual and fluctuating. Expressions varied from person to person, and even from week to week. "Metaphor is seen by most people studying it as not just a linguistic but also a cognitive phenomenon. If you give people different metaphors for the same topic, they reason about it quite differently," she notes.

Semino feels that charities strongly dominate the conversation, and they use military language to fundraise, portraying cancer as a common enemy that needs to be defeated.

Yet author and playwright Stella Duffy, whose solo play

Bring tissues: this musical changes how we talk about cancer

Breaststrokes explored her first breast cancer diagnosis, felt attacked by this kind of message. "What really struck me was that it was asking me to hate some of myself. To be asked to hate some of me, to fight some of me, is really brutal. It doesn't matter how kindly meant it is."

While under no illusion that one musical will bring about a singular cultural shift, Kimmings is optimistic: "One of our cancer patients said, 'I am counting on this show to change the way that we talk about cancer in the public realm', and that for me is a huge ambition but at the same time totally possible." Lobel is hopeful that *A Pacifist's Guide* will allow people to open up about what makes them vulnerable. It is easier for us to voice our own fears about illness and death by agreeing with a character who expresses similar concerns.

Can cultural experiences really change our language? "I think they can," Semino says. "[Scientific papers are] great in their own right, but they don't give you a sense of what it feels like to have those experiences. Narrative has the power to make you feel." Having reclaimed the narrative of her own cancer through writing and performing, Duffy is eager for more people to own the conversation. "I don't want to be reduced," she says. "We're already diminished when we're ill. We don't need to be diminished by the language around it." ■

Mary Halton is a writer and theatre critic based in London

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Evolutionary studies

Advances in scientific understanding and technical ability will always create new fields of study. But how are universities evolving in step with these changes? **Shannon Palus** investigates

Our modern world sits at a nexus of code and people. Consider, for example, that social media platforms, emails and text messages carry information between us with software that caters to our language and emotions. Or that our DNA provides a wealth of information and secrets, decodable with new machine learning tools.

The people building this future, whether at universities or corporations, are often trained in science departments. So it's fitting that some of the fastest-growing fields, which produce the most sought-after graduates, are ones that address the modern mash-up between computers and the living world.

New techniques for managing data are vital, as there's more and more data in our natural world to sift through — thanks, for example, to advances in genome sequencing. As a result, fields like bioinformatics are moving

lightning-fast, says Brian Athey, a professor at the University of Michigan, Ann Arbor. He would know — Athey recently started two new positions aimed at adapting Michigan to the progress of specialties that knit together different fields.

Last year, Athey was appointed co-director of the Michigan Institute for Data Science to bring together faculty from across the university. Data science, according to the Institute's mission statement, is "now

"One of the key challenges is being able to compete for the best new faculty"

widely accepted as the fourth mode of scientific discovery" and is "on a par with theory, physical experimentation and computational analysis".

Many universities are growing analogous institutes. In New York State, the University of Rochester is constructing a 50,000-square-foot building to house its Goergen Institute for Data Science. On the West Coast, the University of California, Berkeley recently

launched the Berkeley Institute for Data Science. These centers foster collaboration and technique sharing between departments.

Entirely new departments are springing up too. Athey's other new role is founding chair of the Department of Computational Medicine and Bioinformatics (DCM&B), which was set up in 2012. It has been a long time coming. For more than a decade, it existed as a smaller degree-granting program at Michigan, and Athey recently helped the program gain department status so it could recruit and hire dedicated core faculty members.

Today, the DCM&B has more than a dozen core faculty members and shares about a dozen more with other departments. Athey anticipates that the number of core faculty will soon double. In some ways, searching for researchers who are deft at interdisciplinary work is the same as hiring anyone: "One of the challenges is being able to compete for the best potential new faculty members," says Athey. "We are looking for folks who are establishing competitive and impactful research records."

For Athey, that means expanding the definition of success beyond the metric favored by any single field, like the number

and quality of papers someone has published. Important work for computer scientists often appears in conference proceedings, whereas researchers who have valuable experience from stints in industry might best show off their work with a list of patents. Others are great at leading large teams — an invaluable skill in a department that communicates across specific specialties and combines different talents.

"If we are to build, grow and flourish as a degree-granting department and training program, we have to embrace the diversity of capabilities necessary to achieve that," says Athey. Indeed, competitive researchers have a résumé that shows off a variety of these accomplishments.

But researchers aiming for a job in an interdisciplinary department don't have to be good at absolutely everything, says Dena Haritos Tsamitis, the director of the Information Networking Institute (INI) at

"We have to embrace the diversity of capabilities necessary to flourish"

Carnegie Mellon University in Pittsburgh, Pennsylvania. Founded in 1989 in response to industry demand, INI fuses computer science, engineering and business. The program looks for faculty that are making waves in their fields, and have "a deep technical background, complemented by an additional discipline" like human factors or policy says Tsamitis. "You have to have your own brand," she says.

Programs like Tsamitis's and Athey's produce students who are in high demand. In 2003, the INI partnered with a new research and education center called CyLab, which was created to address the growing need for experts in security and privacy. Many graduates of INI head off to work in the San Francisco Bay area, while others end up in government positions.

Graduates of the DCM&B work at the usual suspects, such as pharmaceutical and biotech companies. But they also head into jobs that are sometimes "frankly, seemingly, unrelated" to what they studied in school," says Athey, since their skills are so diverse. There are graduates of the DCM&B program stationed at financial service companies, tech giants like Amazon and Facebook, and even working on the back-end of corporations like Walmart. It all goes to show that the future of scientific research is as multifarious as ever. ■

CASE STUDY NEW HORIZONS



HOLLY MENNIGER trained as an entomologist. But one spring while she was a graduate student at the University of Maryland, she found herself swept up in a media whirlwind. Local cicadas (large-bodied, dark-colored flying insects) were emerging for the first time in 17 years, and she was asked to be interviewed on CNN to explain the phenomenon.

That was Menniger's first media experience, just over a

decade ago. In 2014, she accepted a position in a brand new role at North Carolina State University as the director of public science for its College of Sciences. Though the position was created for her, she says that she sees similar roles cropping up at more and more universities.

Her role isn't just about educating the public. As part of the Wild Life of Our Homes project, which examines the diversity of bacterial communities in nine distinct locations within the home, Menniger engaged 1,400 people in collecting data on the microbes that live alongside them, providing data for several publications. And at other universities, researchers are harnessing emerging technology to enlist citizens

in collecting and making sense of data — for example, the Massachusetts Institute of Technology has created an online game called Eyewire that helps researchers map the brain.

There's no one formula for scoring a brand new job like Menniger's, whether in science communication or a similar specialty that engages multiple talents. But it's always true that "networking is incredibly important", she says. In addition to picking out conferences that feature a specialty you'd like to gain experience in, "find your people online", she advises. Heading to social networking communities can allow you to peek into the work of researchers who you might not otherwise run into.

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Faculty Insider

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Position Description: Candidates are invited to apply for an open field tenure-track assistant professorship in the Department of Chemistry and Chemical Biology at Harvard University. The appointment is expected to begin on July 1, 2017. The tenure-track professor will be responsible for teaching at the undergraduate and graduate levels.

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Special Instructions: Please submit the following materials through the ARIS portal (<http://academicpositions.harvard.edu/postings/7065>).

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Contact Information: Helen Schwickrath, Search Administrator, Department of Chemistry and Chemical Biology, Harvard University, 12 Oxford St., Cambridge, MA 02138, Phone: 617-496-8190 Email: helen@chemistry.harvard.edu

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UNIVERSITY OF SOUTH ALABAMA

MITCHELL
CANCER INSTITUTE

Faculty Position(s) in Health Disparities in Cancer Research Program

The Mitchell Cancer Institute at the University of South Alabama (USAMCI) is recruiting faculty at the junior and mid-career stage for its newly developed research program in "Cancer Health Disparities". This program will broaden the institute's overall expertise-base and complement existing research programs at USAMCI. Interested applicants, who are already conducting cancer health disparities research or plan to use their basic and translational research skills to expand their portfolio into this exciting and much needed area of research, are encouraged to apply. Candidates with a track record of independent funding and publications in high impact journals will be given the highest consideration. Successful candidates will be expected to run a vibrant collaborative program supported by external funding. A competitive salary and research start-up package will be provided. Position(s) will be within the Department of Oncologic Sciences, Mitchell Cancer Institute at the University of South Alabama and are tenure-track.

To apply, please send your curriculum vitae, a brief summary of your research plans, and three letters of recommendation to:

Ajay P. Singh, PhD; Professor of Oncologic Sciences & Head, Health Disparities in Cancer Research Program, Mitchell Cancer Institute, 1660 Springhill Avenue, Mobile, AL 36604

or by email to dkeasler@health.southalabama.edu.

Applications will be reviewed and evaluated on an ongoing basis.

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KANSAS STATE
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The Department of Physics at Kansas State University seeks candidates for a tenure-track assistant-professor position in theoretical atomic, molecular, and optical physics, with research focus on light-induced ultrafast dynamical processes in matter. The successful candidate is expected to build and sustain a vigorous, internationally recognized research program that overlaps with and complements ongoing research in the department's large AMO group. The department has outstanding experimental and theoretical AMO physics programs that are directed by 11 faculty members and address an array of forefront problems in AMO science. A significant part of the department's AMO physics research is conducted in the J. R. Macdonald Laboratory (JRML), primarily with funding from the U. S. Department of Energy. Research conducted at JRML includes investigations of the light-driven dynamics in atoms, molecules, and complex systems by employing state-of-the-art ultrafast intense laser and detection techniques, as well as nonlinear optics and optical source development. For a description of current research at JRML see <http://jrm.phys.ksu.edu/>.

The successful candidate must present credentials that justify an appointment at the assistant-professor level, including a Ph.D. (or equivalent degree) in AMO physics or a related discipline, and should demonstrate a strong commitment to teaching and mentoring students at all levels and to serving a diverse population. Applications, including a cover letter, CV, and statements of research and teaching interests along with a list of references should be submitted to:

<http://careers.k-state.edu/cw/en-us/job/497698/assistant-professor-in-theoretical-ultrafast-amo-physics>.

Screening of applicants will start immediately and continue until the position is filled. Background checks are required. Kansas State University is an affirmative action equal opportunity employer and actively seeks diversity among its employees.



WASHINGTON STATE
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Faculty Position in Tissue Regeneration Assistant/Associate Professor School of Molecular Biosciences Washington State University

The School of Molecular Biosciences in the College of Veterinary Medicine at Washington State University in Pullman, WA, seeks to hire an outstanding individual for a full-time tenure-track position at the rank of Assistant or Associate Professor of Molecular Biosciences, (<http://www.smb.wsu.edu/>), who will contribute to a recently funded campus-wide interdisciplinary initiative in Functional Genomics through their research involving progenitor cells and their role in tissue development and repair. Candidates should also use CRISPR-Cas technology in their research.

The successful applicant will have the opportunity to establish their research programs in a state-of-the-art building specifically designed and equipped for biological research. **Duties will include** maintaining a strong, externally funded research program, teaching undergraduate and graduate courses on topics of cell biology and molecular genetics, and participating in service at the school, college, and/or university level. **Job requirements include** a PhD degree in biosciences or a closely related field with a minimum of two years of post-doctoral training in basic science, veterinary medicine, medicine, or a related discipline by the date of hire.

Applicants for an Assistant Professor position must demonstrate the potential to establish and maintain an externally funded research program. Applicants for an Associate Professor position must have established an extramurally-funded research program with a record of peer-reviewed publications and national/international recognition.

The successful candidate must demonstrate commitment and the ability to successfully advocate for diversity and values of diversity. Applications, including a cover letter, curriculum vitae, and statements of research interests and teaching philosophy should be submitted electronically via: <https://www.wsujobs.com> The position number is 71788.

The candidate should also solicit three letters of recommendation to be submitted electronically to the same address. Screening of applications will begin November 1, 2016. Start date is open, and salary will be commensurate with experience. Direct questions to pinter@vetmed.wsu.edu

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UNC Charlotte Department of Bioinformatics is seeking a full time Software Developer. The incumbent will lead the development of bioinformatics web servers, resources and applications. He/she will also work on big data integration and analysis. One focus is the Pathview project. Pathview is an open-source package that maps, integrates and renders a large variety of biological data onto pathways, and produces interpretable graphs with publication quality. Pathview was quickly adopted and widely used by thousands of scientists worldwide. With a major NSF grant recently awarded, Pathview will be fully developed as a systematic solution for pathway based analytics and visualization.

For more information about the research in our group:

<http://pathview.uncc.edu/>
<http://bioconductor.org/packages/pathview/>
<http://bioconductor.org/packages/gage/>

Technical skills:

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- Python or Java
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- Data integration and visualization
- R/Bioconductor is a plus, understanding molecular biology is a plus

Other qualifications:

- Excellent communication and problem-solving skills, attention to detail
- Ability to work independently and in a team
- Self-motivated and disciplined, time and project management skills
- Enjoy building highly quality software, enjoy data analysis
- Proven development experience, publication record is a plus

Education: Bachelor or advanced degree + 3 years working experience in bioinformatics, computer science or related fields.

Salary & benefits for the Research Associate Position: Competitive package

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Application/Inquiry: Preliminary inquiries about the position can be made to Weijun Luo via email weijun.luo@uncc.edu. Please include a short cover letter, CV and the names of 2-3 references. Applicant can submit a formal application electronically at <https://jobs.uncc.edu> EHRA Staff (position 1047).



Full Time Research Associate Biostatistics/Bioinformatics

UNC Charlotte Department of Bioinformatics is seeking to hire a full time Biostatistics/Bioinformatics Scientist. The incumbent will develop statistical/computational methods/tools for high throughput omics (genome, transcriptome, proteome, metabolome etc) data integration, analysis and visualization; apply them to complex diseases/traits and biomedical problems. He/she will participate in the Pathview project. Pathview is an open-source package widely used for based pathway based analytics and visualization.

For more information about the research in our group:

<http://biorxiv.org/content/early/2016/05/11/052878>
<http://bioconductor.org/packages/pathview/>
<http://bioconductor.org/packages/gage/>
<http://pathview.uncc.edu/>

Technical skills:

- Solid statistics training
- Genetics/genomics data analysis (esp. GWAS, Whole Genome/Exome Studies), NGS data analysis, sequence analysis
- R/Bioconductor
- Unix/Linux shell
- Python or Perl
- Version control: svn and git
- R package (or software) development is a plus

Other qualifications:

- Excellent communication and problem-solving skills, attention to detail
- Ability to work independently and in a team
- Self-motivated and disciplined, time and project management skills
- Enjoy computational/statistical method development, data analysis
- Proven research/development experience, publication records

Education: PhD (or Master + 3 years working experience) in statistics/biostatistics, bioinformatics, computational genetics, computer science, or related fields.

Salary & benefits for the Research Associate Position: Competitive package

Start Date: As soon as possible

Application/Inquiry: Preliminary inquiries about the position can be made to Weijun Luo via email weijun.luo@uncc.edu. Please include a short cover letter, CV and the names of 2-3 references. Applicant can submit a formal application electronically at <https://jobs.uncc.edu> EHRA Staff (position 1047).



THE UNIVERSITY OF ALABAMA AT BIRMINGHAM



The University of Alabama at Birmingham (UAB) is one of the premier research universities in the US with internationally recognized and NIH-funded programs in the basic sciences as well as clinical and translational medicine. It is committed to the development of outstanding postdoctoral scientists and has been consistently ranked in recent years as one of the top ten locations among US universities for training postdoctoral scholars.

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- competitive benefits, including maternity/paternity leave and retirement matching for eligible postdocs



UAB is also home to the NIH-funded IRACDA Mentored Experiences in Research, Instruction, and Teaching (MERIT) Program, which provides postdocs with both research and teaching experiences to qualified postdocs; for more info, please see www.uab.edu/meritprogram.

Birmingham is a mid-size city centrally located in the southeast near beaches and mountains and enjoys a moderate climate for year round outdoor activities with a cost of living rate lower than most metropolitan areas.

Visit our website at www.uab.edu/postdocs and select Postdoctoral Opportunities to view posted positions. Send your CV and cover letter to the contact name for those positions for which you are qualified and which interest you.

University of Alabama at Birmingham, Office of Postdoctoral Education, 1720 2nd Avenue S, Birmingham, AL 35294-2182, 205-975-7020/975-7021.

UAB is an equal employment opportunity employer.




Faculty Position Computational Genomics

Department of Bioinformatics and Genomics
College of Computing and Informatics
University of North Carolina at Charlotte

The Department of Bioinformatics and Genomics at the University of North Carolina at Charlotte seeks a tenure-track professor at any career stage to work at our location in the North Carolina Research Campus (NCRC) in Kannapolis. The NCRC is a public-private partnership between corporations, universities and healthcare organizations advancing science at the intersection of human health, nutrition and agriculture.

The NCRC hosts UNC Charlotte, six other UNC system universities as well as Duke University. UNC Charlotte has a leadership position at the NCRC in bioinformatics. We seek applicants wishing to develop a research program in bioinformatics, computational biology and/or computational genomics. This position is part of a larger university-wide research initiative in Data Science and Analytics. The successful applicant will have an earned doctorate with an exceptional record of achievement and will be expected to maintain an externally funded research program that will catalyze a larger group of interdisciplinary scientists. The responsibilities of the position include teaching quantitative skills such as programming and statistical modeling at the graduate and undergraduate level.

We offer a collegial environment, excellent facilities, a competitive start up package, and a competitive nine-month salary commensurate with experience.

Preliminary inquiries about the position can be made to Dan Janies via email djanies@uncc.edu. However, formal applications must be made electronically at <https://jobs.uncc.edu> (position #1074) and must include a CV, contact information for 4 references, and statements on research and teaching. The University of North Carolina at Charlotte is an EOE/AA employer and an NSF ADVANCE institution.

For additional information, please visit our websites at <http://bioinformatics.uncc.edu> and <http://transforming-science.com>.

Tips on Constructing a Winning Grant

Know your program officer.

"Program officers exist to make the grant navigation process a little easier," said Victoria McGovern, a senior program officer at the Burroughs Wellcome Fund. She emphasized that any grant applicant should become comfortable talking with his or her program officer. "Program officers work for you whether they are in the federal government or in the foundation sector," she explained. "Our whole job is to make sure our dollars go to the best investigators who need them."

Potential applicants should seek out program officers for advice either at meetings or via phone and e-mail.

Do your homework and choose the right award.

It's also important for potential applicants to understand the requirements of the grant they are considering.

Applicants should take care not to try to accomplish more than the scope of the grant would permit—a common mistake that program officers see in first-time applicants, said McGovern. "You're applying for your first major grant and you lay out an entire 30 year program, but you're proposing to do it in the next 22 months. Doing that is really common,



and it's a huge way to shoot yourself in the foot," she said. "It's human nature—you get excited and want to tell the whole story."

One strategy she suggests to avoid oversell in a grant application is to use your accompanying letters of recommendation strategically. "You could talk to your advisor about describing some of your research future in the letter," she said.

Another tip is to identify the particular study sections applications are likely to be targeted toward and to learn about the members of that section.

If at first you don't succeed... While it's frustrating to put in all the work necessary for a grant application only to not have it funded, it is important that

researchers who are turned down for a first-time grant application revise and resubmit. Do not give up.

Don't rush, follow instructions and leave time to proofread.

Proofreading and following instructions should go without saying, but it's a common suggestion from funding agencies. And it's not just young investigators who run into trouble following instructions on grant applications; plenty of established researchers try to bend the rules, too.

Never underestimate the value of proofreading.

BURROUGHS
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Perelman School of Medicine at UNIVERSITY of PENNSYLVANIA

Assistant/Associate/Full Professor of Genetics in the Institute for Biomedical Informatics

The Department of Genetics and the Institute for Biomedical Informatics at the Perelman School of Medicine at the University of Pennsylvania seek candidates for an Assistant, Associate, or Full Professor position in the tenure track. The Department of Genetics and the Institute for Biomedical Informatics comprise faculty with diverse investigative interests and close affiliations with the neighboring Children's Hospital of Philadelphia.

The successful applicant will have extensive experience in computational biology and/or biomedical informatics as applied to human genetics and genomics. Applicants should have a defined biological research interest and experience in collaborating with bench scientists. Responsibilities include developing and carrying out an independent research program and participating in graduate and medical school education. Applicants must have a Ph.D. and/or M.D. degree and have demonstrated excellent qualifications in research and education. The successful applicant will have the opportunity for affiliation with Penn's Department of Computer and Information Science.

Attractive laboratory space and substantial resources are available.

For more information about the Department of Genetics visit www.med.upenn.edu/genetics and about the Institute for Biomedical Informatics visit www.upibi.org.

Apply for this position online at:

https://www.med.upenn.edu/apps/faculty_ad/index.php/g/d4396

Associate/Full Professor of Genetics

The Department of Genetics at the Perelman School of Medicine at the University of Pennsylvania seeks candidates for an Associate or Full Professor position in the tenure track. The Department of Genetics comprises a faculty with diverse investigative interests and close affiliations with the neighboring Children's Hospital of Philadelphia and the Wistar Institute.

The successful applicant will have extensive experience in original investigation in the fields of human genetics, model systems genetics, and/or regulation of eukaryotic gene expression. Responsibilities include directing an independent research program and participating in graduate and medical school education. Applicants must have a Ph.D. and/or M.D. degree and have demonstrated excellent qualifications in research and education.

Attractive laboratory space and substantial resources are available.

For more information about the Department of Genetics, visit www.med.upenn.edu/genetics.

Apply for this position online at:

https://www.med.upenn.edu/apps/faculty_ad/index.php/g/d4395

To ensure full consideration, applicants are encouraged to apply by October 31, 2016. Please submit a cover letter, curriculum vitae, and a 2-page statement of research interests, as well as the names of 3 references.

We seek candidates who embrace and reflect diversity
in the broadest sense.

The University of Pennsylvania is an EOE. Minorities/Women/Individuals with disabilities/Protected Veterans are encouraged to apply.

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NewScientist Jobs

Fellowships for Postdoctoral Scholars at Woods Hole Oceanographic Institution



New or recent doctoral recipients with research interests associated with the following are encouraged to submit scholarship applications prior to January 5, 2017.

Departments - Awards related to the following areas are anticipated: Applied Ocean Physics & Engineering; Biology; Geology & Geophysics; Marine Chemistry & Geochemistry; Physical Oceanography; and in cooperation with the USGS laboratory located on the WHOI campus.

Institutes - Each Institute fosters interdisciplinary research addressing critical issues, and we will award a scholarship to support related research: Ocean and Climate Change Institute; Coastal Ocean Institute; Ocean Exploration Institute; Ocean Life Institute

The National Ocean Sciences Accelerator Mass Spectrometry Facility (NOSAMS) will award a fellowship in the development and implementation of new techniques in marine science radiocarbon studies.

A joint USGS/WHOI award will be given to a postdoc whose research is in an area of common interest between USGS and WHOI Scientific Staff. The individual will interact with both USGS and WHOI based advisors on their research.

Awards are competitive, with primary emphasis placed on research promise. Scholarships are 18-months with an annual stipend of \$58,500, a research budget and eligibility for health and dental insurance. Recipients are encouraged to pursue their own research interest in association with resident staff. Communication with potential WHOI advisors prior to submitting an application is encouraged.

Further information may be obtained at:

www.whoi.edu/postdoctoral

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Berkeley

Department of Chemistry
Faculty Position in Chemistry

The Department of Chemistry, at the University of California, Berkeley, invites applications for one faculty position at the assistant professor level with an expected start date of July 1, 2017. Preference will be given to candidates in the broadly defined fields of inorganic and/or materials chemistry. However, we will consider creative and energetic candidates who show extraordinary promise or accomplishment in research and teaching in any area of chemistry. The basic qualification for this position is a Ph.D. or equivalent degree in chemistry or a related field at the time of application.

All applicants should submit their most recently updated curriculum vitae and a statement of research and provide at least three but no more than five letters of recommendation. A cover letter and a statement of teaching are optional. Applications should be submitted electronically through our web-based system at: <https://aprecruit.berkeley.edu/apply/JPF01131>.

All recommendation letters will be treated as confidential per University of California policy and California state law. Please refer potential referees, including when letters are provided via a third party (i.e., dossier service or career center), to the UC statement on confidentiality (<http://apo.berkeley.edu/evaltr.html>) prior to submitting their letters.

The deadline for receipt of application material is November 1, 2016. Please direct questions to Lauren Nakashima (lnakashima@berkeley.edu).

The University of California is an Equal Opportunity/Affirmative Action Employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age or protected veteran status. For the complete University of California nondiscrimination and affirmative action policy see: <http://policy.ucop.edu/doc/4000376/NondiscrimAffirmAct>.

UC Berkeley is committed to diversity in all aspects of our mission and to addressing the family needs of faculty, including dual career couples and single parents.

EDITOR'S PICK



A final test of our universe's reality

From Richard Weeks

Do we live in a digital simulation, asks Anil Ananthaswamy (3 September, p 30). Perhaps we could try to decide the question by crashing it.

Presumably, the more heavily we load the simulation, the more likely it is to fail. By running ever more digital simulations within our own universe, we might perhaps be able to bring our parent simulation to its knees – although we might then not be in a fit state to notice.

Doing too much quantum computing might also not be wise. Even thinking too much and making too many decisions could be dangerous. If such seemingly innocuous acts really do spawn universes by the gazillion, we should spare a thought for our poor host simulation.

Of course, it could be that what's really going on bears no resemblance to our limited concept of what a simulation can be like – whether that be a digital one with detectable granularity in space and time, or an analogue one with inherent noise giving rise to underlying randomness.

Felixstowe, Suffolk, UK

The editor writes:

■ The Silicon Valley rumour mill has it that there are already well-funded projects looking for ways to “break us out” of the simulation. Bad news for those of us who like living in it, perhaps.

In defence of burning wood

From James Pringle

Regarding the carbon accounting scam you report (24 September, p 20), it should be recognised that mature trees take in less carbon per hectare than young, fast-growing ones. Restocking woodland after harvesting seems to be a better sequestration bet than simply leaving trees standing.

Better still is to use the harvested timber in furniture and buildings. That has the added benefit of displacing carbon-heavy materials such as concrete. Galashiels, Selkirkshire, UK

From Liegh White

False accounting? I cannot see how you can argue that releasing carbon from coal, which has been sequestered for 300 million years, is ever preferable to burning a tree that gives ground to saplings, which in turn will sequester as much carbon as released by that tree, over the next 50 years.

False accounting is not allowing for the carbon emissions tied up in imported goods we consume. False accounting sets the price of carbon-neutral electricity from wind and photovoltaics side by side with coal, oil and gas to show how “expensive” it is, taking no account of the planetary havoc caused by releasing fossil carbon.

I'm keeping my log burner with a clear conscience.

Keyworth, Nottinghamshire, UK

From Nina Skroupska, Renewable Energy Association

You do not take into account the rigorous external scrutiny and internal commitment to sustainability demonstrated on an ongoing basis by the biomass sector and its leading companies. Regulation strictly prohibits using any wood or biomass from primary forests, highly biodiverse grassland or protected nature for energy generation.

The wood used is typically from

thinnings, treetops, limbs and sawmill residues, as well as misshapen and diseased trees not suitable for other use. The UK government holds the British biomass industry to some of the highest standards in the world. The wood and bioenergy sectors do not claim to be completely carbon-neutral: there are some emissions from transporting and producing the fuel. London, UK

The tragic fiasco of trans fats

From Craig Sams

Luke Allen calls for a ban on trans fats (10 September, p 18). This is long overdue. In 1993 my company Whole Earth Foods launched a trans-fat-free spread, branded Superspread. Other manufacturers objected to our advertising: the Advertising Standards Authority banned it, effectively killing our product.

We presented the ASA with the medical evidence, which was abundant 23 years ago. They accepted its validity but said we violated their code because we were “appealing to fear” by suggesting trans fats could damage your heart health.

When Denmark banned trans fats the food industry replaced them with coconut and palm fats, and the EU was faced with a rapeseed oil glut, as that was the oil that was mostly hydrogenated. So the Renewable Transport Fuels Obligation required rapeseed oil to be blended with diesel.

That requirement overshot. So we are now deforesting Indonesia to grow palm oil to make up the quota for vegetable oil in diesel.

If there is anything to be learned from this tragic fiasco that continues to cost tens of thousands of lives annually and blights many more with ill health, it is that agricultural policy should never trump health policy.

Hastings, East Sussex, UK

Nostalgia is no worse than it was

From John Davnall

Teal Burrell reports that there is evidence of a “genuine trend” towards nostalgia becoming more common (24 September, p 36). This can hardly be surprising given that we are living longer, so having more experiences to be nostalgic about and more time to indulge ourselves in nostalgia.

And I suggest, although without research to support this claim, that in all manner of fields – technology, society, politics, the arts – the old is being replaced by the new at increasing rates. Even without longer lives, we would be able to reminisce about ever more lost features of our past. Modern communications make it easy to provoke nostalgia in others by drawing their attention to the things that are going or have gone. Manchester, UK

DNA's discovery has twists in its tale

From George Wilkins

Rosalind Franklin's images of DNA in 1951 were not the first (27 August, p 39). William Astbury obtained blurred X-ray images of DNA in 1938.

My father Maurice Wilkins, with Raymond Gosling, obtained the first clear X-ray diffraction image of DNA at King's College London in 1950. He presented this at a conference in Naples, Italy, in 1951. It suggested a regular molecular structure and sparked the interest of James Watson. Franklin was invited to King's the same year to help build on these promising initial results.

In 1952, Wilkins also obtained clear “X” shape images from *Sepia* sperm and shared these with Crick and Watson, who said they “should provide sufficient detail for a rigorous interpretation of the pattern”.

“Why did we lose this fight for elephants and lions with all the evidence of tragic rapid population decline?”

Shani Rosenzweig is not happy that the CITES conference didn't ban trade in elephant and lion parts (8 October, p 6)

The story of DNA's discovery has parallels with the molecule itself: it's full of twists and turns.
London, UK

Cars that are just a bit driverless

From Sam Edge

Hal Hodson says that Uber customers in Pittsburgh may “find themselves picked up by a driverless car – with a human driver on standby” (1 October, p 24). It is noteworthy that most trials of the technology require the subjects, sorry, passengers to sign waivers of liability against loss, injury or death before setting off. Coverage of this guff reminds me of the 50s when credulous folk were told we'd be buzzing around in personal flying cars by 1980.

The gap between achieving 90 per cent of true driverlessness and the 99.999 per cent that will be required by insurers and, I hope, by legislators, is much harder to cross than the 0 to 90 bit we have covered so far.
Ringwood, Hampshire, UK

The population of Utopia was what?

From David Flint

Andrew Robinson makes an interesting case for 700 years of peace and equality in the Indus Valley civilisation (17 September, p 31). It would be nice to believe it. But I'd expect a settled peaceful population to have a high birth rate: it's hard to see how this would not lead to conflict for finite resources.

Might they have had effective birth control – or very strong social discipline, as Thomas More proposed in his original *Utopia*? It would be good to know, since living within finite resources is a problem that we have yet to solve.
London, UK

Less slippery consciousness

From Jason Hoelscher

Is consciousness “real” or “a trick of the mind” (3 September, p 28)? The idea of mind itself is slippery,

so explaining slippery potential entity 1 as a trick of slippery potential entity 2 quickly gets into murky territory.

The word “trick” is loaded with implicit value judgments: might a better word be “byproduct,” or perhaps “epiphenomenon”?

It may be more accurate (although admittedly still slippery) to say the mind is an emergent phenomenon of certain recursive processes of the brain, and that consciousness in turn is a byproduct of a mind that has achieved enough density and complexity to become aware of its processes of awareness.

Consciousness, considered this way, is simply our sense of being a being that is aware of being an aspect of space-time.
Statesboro, Georgia, US

Making bread for the dead

From Andy Green

Emily Benson says that some loaves of ancient Egyptian bread “were made with ingredients we

would consider inedible today, like chaff and straw” (20 August, p 25). Isn't it possible that these ingredients were used only for ritual burial bread that no one was actually going to eat?
Epsom, Surrey, UK

Darwin's burial and earthworms' woes

From Jill Bennett

Caroline Waddams finds it a tragedy that Charles Darwin was interred in a “sterile” vault in Westminster Abbey, instead of with worms in a churchyard (Letters, 24 September). Darwin himself would not have been sterile, especially if he had food inside him at time of death.

Worms do not live deeper than the nutritional topsoil, which is usually about 30 centimetres deep. So the worms would have considered themselves buried alive 6 feet under, which would have distressed Darwin if he had a particular fondness for them.
London, UK

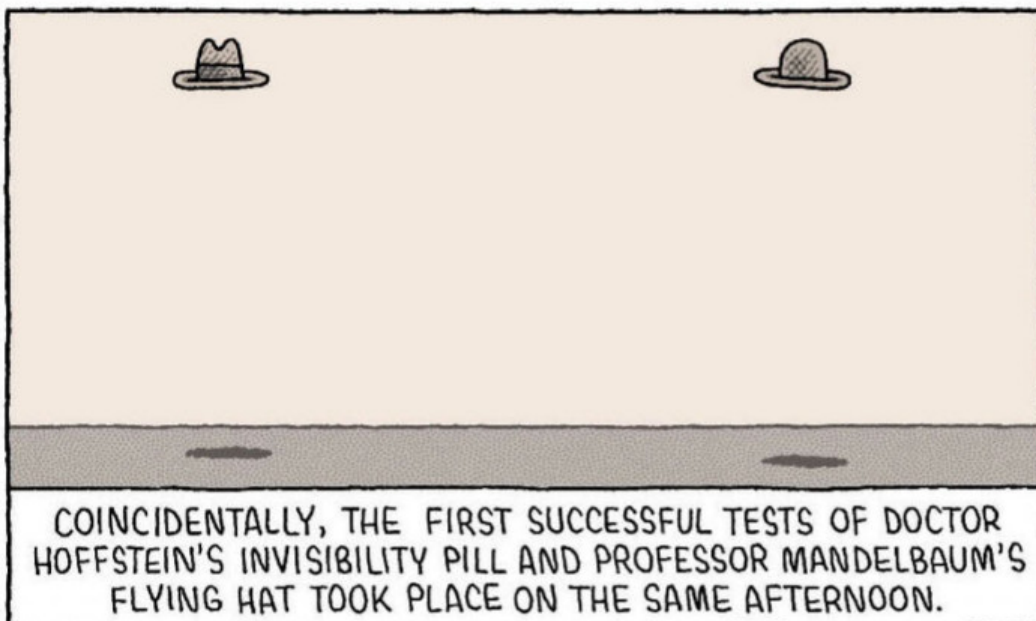
For the record

- Attempts in the 1990s to create babies using DNA from three people led to two fetuses with genetic disorders (1 October, p 8).
- The Harvard neuroscientist studying children living in Romanian orphanages is Charles Nelson (1 October, p 5). Apologies.
- Getting warmer: it is the increase in global temperature above baseline that is expected to soar way past 2 °C (1 October, p 6).

Letters should be sent to:
Letters to the Editor, New Scientist,
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Include your full postal address and telephone number, and a reference (issue, page number, title) to articles. We reserve the right to edit letters. Reed Business Information reserves the right to use any submissions sent to the letters column of *New Scientist* magazine, in any other format.

TOM GAULD





JUST the thing for the dead-eyed among us: beauty company Mirenesse promises more youthful skin with an eyecare serum "inspired by the gene science of Epigenetics (above the gene), which can be thought of as a 'Youth Switch' for skin cells". The company adds that the tonic "will turn the lights back ON in the ageing skin cells".

Feedback once had a solar keratosis cut out of the side of our head, in which our ageing cells were a little too turned on. Our doctor recommended not exciting them any further, so we'll give this product a miss.

Enno Davids, who brought the serum to our attention, notes that the cream also contains "stem cells", from, er, Himalayan red rice and carrots. So a few drops could revive your peepers - or your paella.

PAUL McDEVITT FOLLOWING the Conservative party conference in Birmingham, Feedback can't help but wonder if a problem with the catering is

distracting minds from Brexit.

A key plank in Britain's post-European Union fortunes is formerly disgraced defence secretary Liam Fox, now heading the Department for International Trade. During the conference, his office announced an opening business pitch with the quixotic Twitter declaration: "France needs high quality, innovative British jams & marmalades." Perhaps winning a Nobel prize that can only be described in pastry shapes (8 October, p 6) demands a technically proficient jambassador?

MEANWHILE, would-be prime minister Andrea Leadsom, no stranger to getting into a pickle herself (16 July), expressed hopes that young Britons would take on the low-paid, fruit-picking work previously carried out by EU migrant workers. Andrew R. T. Davies, the Conservative who leads the opposition in the Welsh

Assembly, vowed that the party would make "breakfast" a success (but will it be full English or continental?).

While the odd focus on food at the conference gives Britain's economic plan the air of a bake sale, Brits are left to worry how badly they'll be jarred by Brexit when negotiations start in March - an innovative jam of our own making.

IN A twist on the tale of the golden goose, a 35-year-old employee of the Royal Canadian Mint has been found in possession of a CAN\$180,000 nest egg, allegedly smuggled out of the building in gold nuggets hidden about his person. Police were alerted after a bank teller noticed repeated deposits from Ottawa Gold Buyers appearing in Leston Lawrence's account.

He is alleged to have hidden several pucks of gold - each around 5 centimetres across and some 210 grams in weight - in his backside to evade the metal detector at the mint's exit. However, the mint was unable to prove Lawrence's gold was stolen, or indeed that any was missing from his workplace.

When investigators discovered a tub of Vaseline in Lawrence's work locker, it was left to one member of security staff to test the prosecutor's theory, certainly achieving a new gold standard in employee dedication.

Graeme Faris, who forwards us this story, notes that the case is being presided over by one Justice Peter Doody.

A DIVISIVE topic: Lance Hartland writes to shed light on the curious use of maths on Greenland sales tags (24 September). "My mother was born in Denmark in the 1920s, and I remember her saying that she was taught that the ÷ sign meant 'minus' and the : sign meant 'divide'."

As Greenland is part of the Danish realm, he supposes that old habits are dying hard among the glaciers. Feedback thinks this sounds positively confusing and can't help but note that the ÷ symbol, or obelus

(for that is its name), was historically used to denote questionable passages in manuscripts.

FLYING VISIT: "Take only pictures and leave only footprints," said many a naturalist. But a sign on Green Island, part of Australia's Great Barrier Reef, cautions Lance Stewart against even that, telling him: "Do not sit or stand."

"Luckily I was only hovering around at the time," he says.

ALSO left perplexed is Karyn Houssenloge, who found herself behind a truck on which a sign warned: "Caution. Truck constantly stopping and reversing." She says that "despite the warning, it was actually in neither of these states but going forward".

MORE open-ended promises and the companies that deliver them - or fail to. Barrie Wells finds the most expensive service from Parcelforce, branded Global Express, offers shipping windows



"from one day". The cheapest option is capped at "4-6 days".

"I paid twice as much for the former, because I wanted my parcel to arrive as quickly as possible," says Barrie. "It took nine days. I have no recourse, because they are technically correct, it was delivered in one day or more."

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Peter Watson discovers a company acting on instinct as revealed by the *Globe and Mail*, which tells him: "Wells Fargo plans to eliminate sales goals sooner than planned."

Bent out of shape?

Earth is an oblate spheroid, which means its surface curves most at the equator. This means ancient continents that moved from lower to higher latitudes would no longer be shaped to “fit” the curvature of the Earth. Is this effect at all significant, and would it be enough to contribute to their breaking up? Is it operational today?

■ Tectonic plates, which cover Earth’s surface and carry the continents, are flexible on large scales of time and space (hundreds of thousands of years and thousands of kilometres). This can be seen in the phenomenon of subduction, where one plate is pushed under another, for example the Pacific plate underneath Japan. Friction and mechanical stress during this process lead to volcanism and earthquakes.

Another demonstration of tectonic plates’ flexibility is the folding of rock to form mountain ranges like the Alps or the Himalayas, which occurs where two tectonic plates collide.

The bends of the tectonic plates during mountain building or subduction are much sharper than those needed to adapt their curvature to the oblate shape of Earth. This means that the latter effect can be safely neglected as a source of cataclysmic geological events.

*Thomas Otto
Technology department
CERN, Geneva, Switzerland*

■ The effect is minimal and would not significantly add to the breaking up of the plates. Most of their movement is thought to be caused by the dragging effect of currents in the mantle, the layer below Earth’s crust. The plates are relatively thin compared with the diameter of Earth and their own surface area, and they are also quite flexible. At the rate they move, they readily accommodate themselves to Earth’s shape. In fact, plates at subduction edges flex considerably more than is required to fit the curvature of the globe.

*Brian King
Barton on Sea, Hampshire, UK*

Surf’s up

On a day of meagre waves, surfers often say that one should wait for the tide to turn because the waves will get bigger when the tide is “on the push”. Is there any reason to believe that waves will increase in height with an incoming tide?

■ In brief, yes. Surf arises from swells that may have travelled thousands of kilometres. If swells travel over deeper areas, they gain speed, and thereby stretch out and lose height. Conversely, as depth decreases towards the shore, the shoaling water slows the leading zone of each swell. The water behind piles up until it eventually curls into a breaking wave. The faster the wave, the more energy it has, and the more generously it breaks.

Ebbing water moves away from the beach. This reduces the forward velocity of incoming swells relative to the beach, sapping the surf’s energy. Similarly, incoming tides increase the waves’ velocity towards the beach, increasing the energy.

You might object that tides ebb and flow too slowly to be noticeable, and for swift waves that is true. But for smaller, slower waves like those in the North Sea, the relative difference is greater.

Kinetic energy increases with the square of the velocity, so, in surfing, a difference of just 2 kilometres an hour in wave speed can turn stingy ankle-busters into generous rollers.

*Jon Richfield
Somerset West, South Africa*

Upright snooze

Why do some animals, such as humans, lie down to sleep, whereas others, such as elephants and giraffes, stand?

■ There are several factors that affect an animal’s sleeping style: how easily it can get up and stay up, how easily it can lie down, how comfortably it can stay down and what kinds of threats it faces in its environment.

In general, the larger a land animal, the less it likes getting up or staying down, so very heavy animals such as elephants don’t lie down much. It is hard for recumbent elephants to breathe or to rise suddenly.

Instead, their legs are adapted to support their weight vertically, so that a healthy elephant can stand indefinitely and sleep lightly, possibly leaning against something. It will only lie down for a deep sleep when it feels secure enough.

Giraffes sleep even less; they are more vulnerable to predators. A cat, pig or goat can take off quickly from a sleeping start, so they are free to lie down and curl up.

Cattle and horses are somewhere near the break-even point. They keep to their feet as a rule, but can get tired enough to rest, or nap, lying down. In the wild, however, they rarely lie down when they are nervous about predators.

*Antony David
London, UK*

■ As a qualified field guide with extensive experience of elephants in the wild, I can assure your readers that they sleep lying down.

*Rod Murphy
Gauteng, South Africa*

This week’s question

COOLING-OFF PERIOD

In the context of what is known about current climate change, what caused the Little Ice Age, generally thought to have been at its coldest in Britain in the mid-17th century?

*Christopher Smith
Whitstable, Kent, UK*

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